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THE FESTIVUS
A publication of the San Diego Shell Club

ISSN 0738-9388

Volume: XXVIII December 27, 1996 Supplement

An Atlas of Cowrie Radulae

(Mollusca: Gastropoda: Cypraeoidea: Cypraeidae)

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AN ATLAS OF COWRIE RADULAE (MOLLUSCA: GASTROPODA: CYPRAEOIDEA: CYPRAEIDAE)

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Abstract: The radulae of 202 species of cowries (Mollusca: Gastropoda: Cypraeoidea: Cypraeidae) are figured over a range of magnifications with drawings, conventional light microscopy and scanning electron microscopy. Radular tooth form and structure are briefly described, and attention is focused on some of the functional implications of tooth structure. The radulae are arranged in 13 patterns based primarily on the form of the central tooth. The patterns, originally intended merely as a convenient means of comparing like with like, are remarkably consistent with M. Schilder and F. Schilder's (1971) generic arrangement of the cowries. In the 13 patterns, 18 of the 21 genera which include Recent cowrie species retain their integrity, representing either monogeneric patterns (i.e., all sixteen species of *Lyncina* are exclusive to one pattern) or included with other genera in a pattern (i.e., the mauritiana pattern is comprised of species in four genera). In each of two genera, a single species is aberrant: 15 species of *Palmadusta* fall into the cicercula pattern, one into the limacina pattern; five species of *Pustularia* fall into the cicercula pattern, one into the erosa pattern. Only in *Blasicrura* is the genus fragmented and the 15 species are distributed among five of the 13 patterns.

INTRODUCTION

Herein are recorded figures of the radulae of 202 species of cowries (Mollusca: Gastropoda: Cypraeoidea: Cypraeidae), over a range of magnifications with drawings, conventional light microscopy and scanning electron microscopy. This atlas is based on available cypraeid radulae, and thus omits several species. We use the term "species" loosely to include cowries that some authors call species, subspecies, or in some cases even forms. Some nominal species such as *Notocypraea bicolor* have been included because we felt that photos of their radulae might contribute to the investigation of their validity. Although we illustrate, and to a limited extent describe, radular tooth form and structure, we do not consider function of the array of shapes and structures displayed in cowrie radulae in detail, and we limit phylogenetic implications to our recognition of the genera adopted by F. Schilder and M. Schilder (1971), and our arrangement of the radulae in several distinctive radular patterns. Because of the uncertainties of homologies among radular teeth, radular tooth terminology is entirely descriptive: the terms central or rachidian, lateral, sub- or inner marginal and marginal or outer marginal merely indicate placement in the radular row and have no phylogenetic implications.

ABBREVIATIONS

The following abbreviations are used in this work:

AMNH	American Museum of Natural History (New York)

AMS	The Australian Museum (Sydney)
ANSP	Academy of Natural Sciences of Philadelphia
BPBM	Bernice P. Bishop Museum (Honolulu)
CAS	California Academy of Sciences (San Francisco)
DMNH	Delaware Museum of Natural History (Wilmington)
LACM	Natural History Museum of Los Angeles County
MNHN	Muséum National d'Histoire Naturelle (Paris)
OM	Optical microscope
SAM	South Australian Museum (Adelaide)
SC	Schilder Collection, Zoologisches Museum, Museum für Naturkunde der Humboldt Universität (Berlin)
SEM	Scanning electron microscope
SIO	Scripps Institution of Oceanography (La Jolla)
UCSD	University of California, San Diego
WAM	Western Australian Museum (Perth)
ZISP	Zoological Institute of the Russian Academy of Sciences (St. Petersburg)

THE COWRIE RADULA

The Radula

The radula (Figure 1) is a unique feeding organ and one of the distinguishing features of the mollusks. It is present in all the classes of living mollusks except the bivalves. Fundamentally it is a tooth-bearing chitinous ribbon lying over a muscular bulb (the odontophore) in the mouth (Figure 2A). The teeth, constantly worn away in front and constantly replaced on the inner end of the ribbon, are positioned regularly alongside one another in seemingly transverse rows and behind one another in longitudinal series. They differ in number and shape from species to species, though remaining fairly constant within one species. In the cowries (Cypraeoidea: Cypraeidae) there is a central tooth (rachidian) and three teeth on either side (Figure 1); in top shells (Trochoidea: Trochidae) (Figure 3A), nerites (Neritoidea: Neritidae) (Figure 3B) and in others there is a large central tooth, with a fan of smaller teeth on each side; in the cones (Conoidea: Conidae) (Figure 3C) individual harpoon-like teeth, at times more than 12 mm long, and carrying neurotoxins, are ejected one at a time from the mouth of the cone.

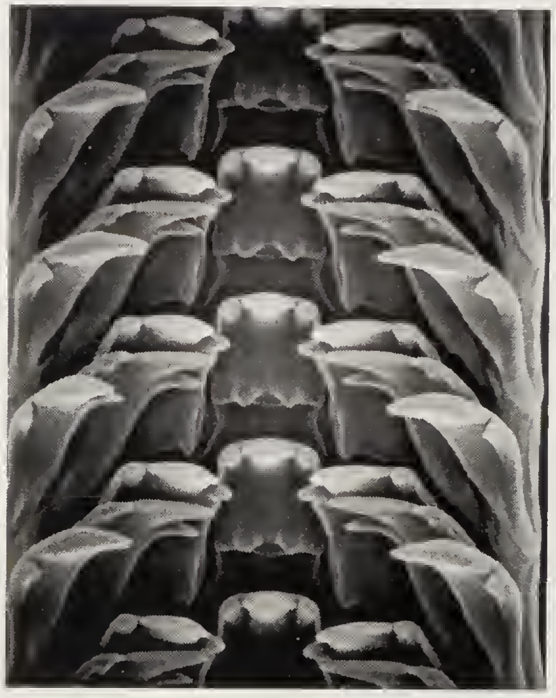

Figure 1. Cypraeid radula (*Erronea walkeri*).

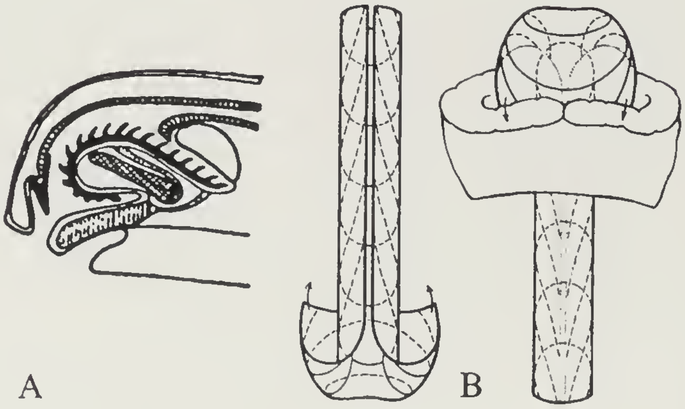

Figure 2 A-B. Schematic radula drawings. (A) radula on buccal bulb (B) slit cylinder model from Morris & Hickman, 1981.

The radular ribbon in the cowries is usually about one-half to three-quarters the length of the shell, its width about 5 percent of the length of the ribbon. A single cowrie radula may contain more than 1000 individual teeth, each in its own orderly row (Figure 1) which includes a central tooth, two lateral teeth, two submarginal teeth and two marginal teeth. The teeth on the right of the central are the mirror images of those on the left, in a pattern termed taenioglossan (from the Greek *taenia*, a band). A generalized taenioglossan radula of *Littorina* (Figure 4A) and that of *Erosaria* (Figure 4B) are shown in Figure 4, along with radular teeth of gastropods assumed to be related to the cowries. In these presumed relatives, some of the teeth are finely denticulate, and the marginals in *Simnia* (Figure 4H) are so denticulate as to resemble those of some nerites.

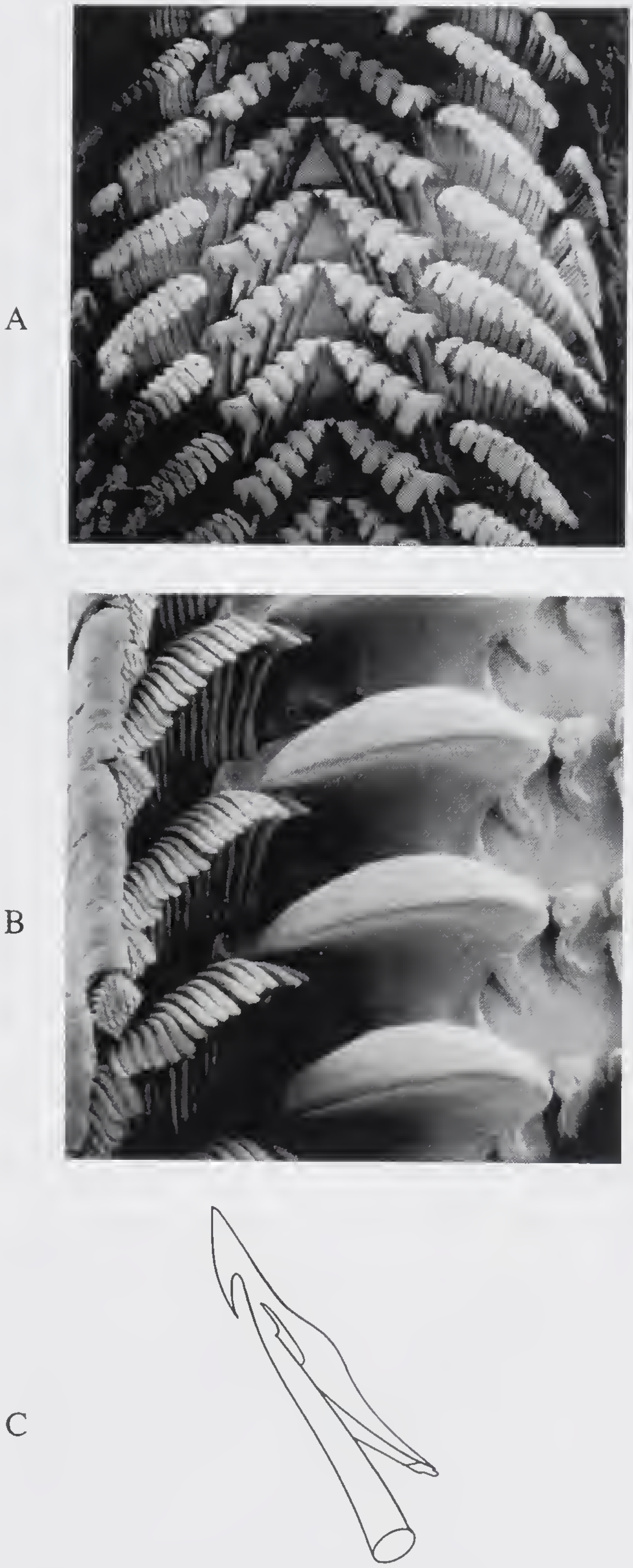

Figure 3 A-C. Some gastropod radulae. (A) radula of top shell (Trochidae: *Synaptocochlea concinna*) (B) radula of nerite (Neritidae: *Nerita picea*) (C) radula of cone (Conidae: *Conus striatus*).

Radular Tooth Structure, Function and Variation

The classical picture of a gastropod is one in which the radula is protruded (Figure 2A) and manipulated back and forth over a bending plane, scraping up food of various types, including seaweed, sponges and detritus. It has now been demonstrated, however, that the radula in grazing gastropods is more usefully represented in terms of a "slit cylinder model" (Morris & Hickman, 1981) in which the tooth-rows assume a tight semicircular configuration during feeding (Figure 2B). That configuration is apparent in Figure 5, which depicts a specimen of *Cypraea tigris* Linnaeus, 1758, grazing on the side of an aquarium.

The major features of the cowrie radula are shown in Figure 1. The following descriptions derive from OM photographs and drawings which provide details of internal structure, and SEM photographs which show external details but do not reveal internal structure.

Usually, only the central tooth is fully visible, and the other teeth in a half row overlap each other. In some cases, however, every tooth is visible (*Luria isabella,* Figure 147), and in others no single tooth is visible (*Monetaria annulus,* Figure 57). Separation and overlap are to some extent characteristic of the species, but can also be artifacts of the mounting technique.

Each tooth consists of three main parts (Figure 6): cusp, shaft and base (or basal platform). Cusps are those parts of the tooth that engage the substrate during feeding, and are usually in the form of triangular distal projections terminating in a point. All seven teeth are tricuspid in most of the cowries; however, we illustrate 5-cusped central teeth in 48 species and note lateral and marginal teeth which bear more than three cusps in some of those species.

The cusps differ not only in form but in composition from species to species: in *Lyncina lynx* (Figure 7A-C) they are pendulous while in *Cypraea tigris* (Figure 7D) they are apparently reinforced with a material which takes on a deep stain with potassium permanganate and similar dyes, providing some indication of internal structure in the radular tooth.

The cusps on all of the radulae illustrated are apparently smooth, lacking the fine serrations figured by Vayssière (1923, Figures 58, 69, 73, and 189) as "*Cypraea lurida*," "*C. turdus*," "*C. spurca*" and "*C. thersites*." We have not detected serrations in these species in either our OM or SEM pictures.

The chitinous shaft and the base of the tooth sustain compressional, tensional, and shear forces to which the teeth are subjected during feeding. Chitin is

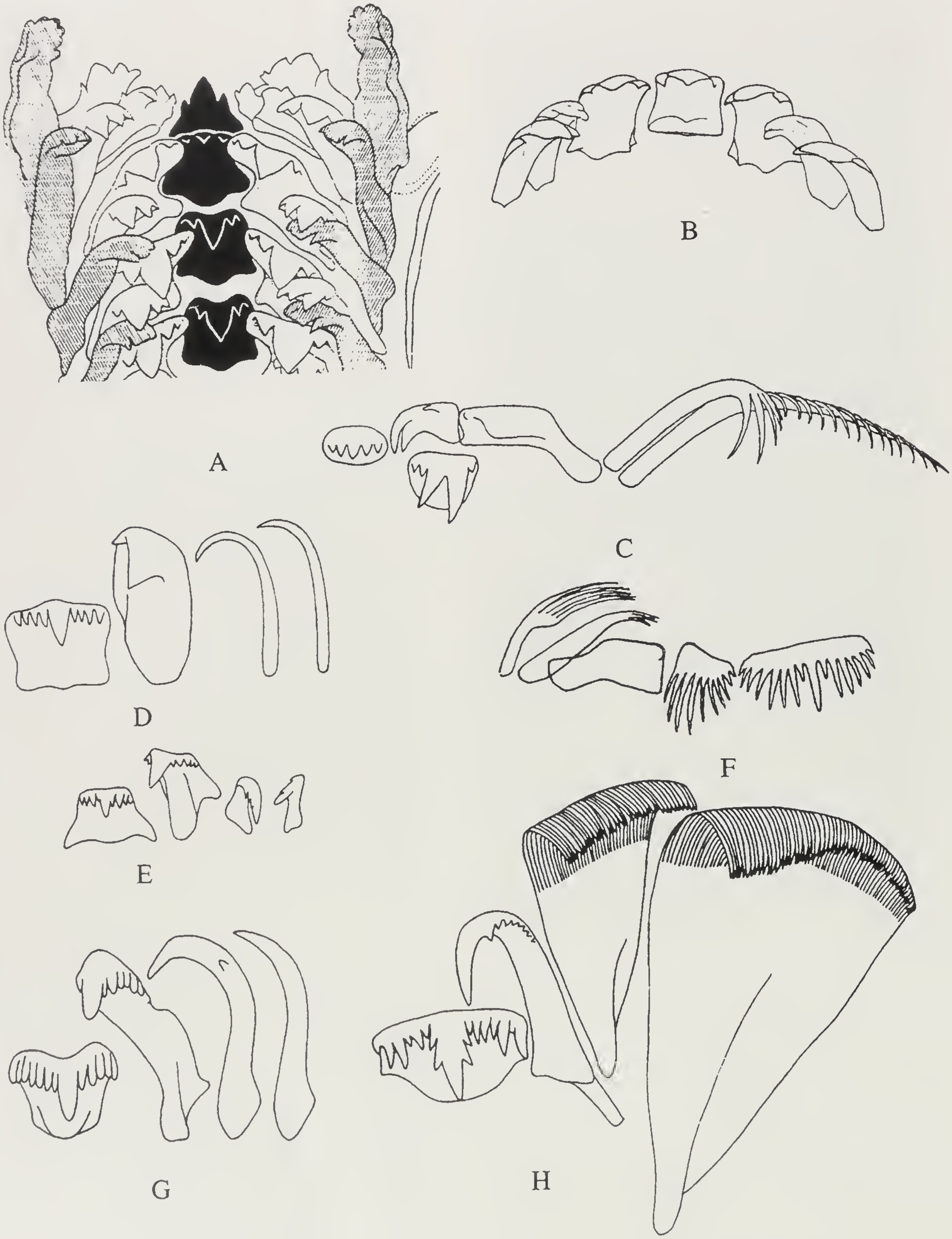

Figure 4 A-H. Taenioglossan radulae and radular teeth of presumed cowrie relatives, (A) *Littorina littorea* adapted from Franc, 1968 (B) *Erosaria guttata* after Schilder [SC] (C) *Cyproterina (Jenneria) pustulata* after Thiele, 1931 (D) *Trivia europaea* (E) *Trivia oryza* (F) *Pseudocypraea adamsonii* after Thiele, 1931 (G) *Erato voluta donovani* (H) *Simnia acicularis* (4 D,E,G,H after Bandel, 1984).

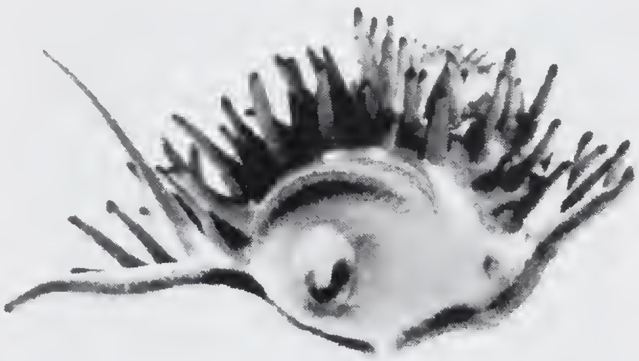

Figure 5. *Cypraea tigris* feeds by moving the radula, here shown protruding from the mouth, across the surface of rocks. The siphon, mantle papillae and the tentacles frame the mouth and proboscis. Photo by O. Schoenberg-Dole, *in* E. A. Kay & O. Schoenberg-Dole (1991).

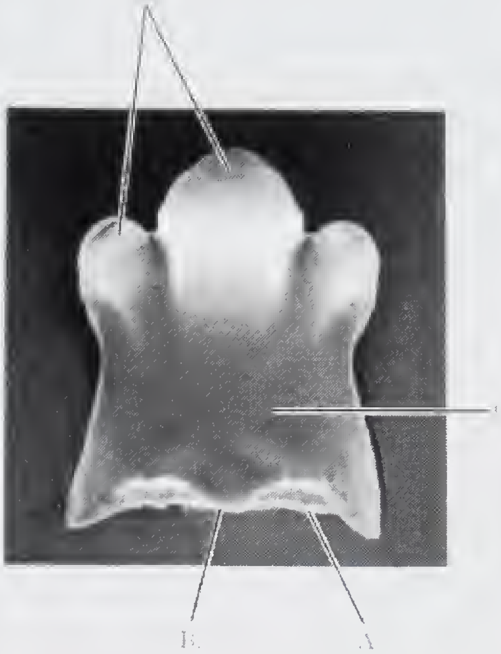

Figure 6. Parts of cowrie central tooth (*Monetaria annulus*). (A) base (B) basal denticle (C) shaft (D) cusps.

a fibrous elastic material, and tooth flexibility is associated with the extent to which its chitinous composition is modified by mineralization or tanning. In the cowries, both shaft and base are enhanced by the addition of medial or basal denticles and by ridges (*Cypraea tigris*, Figure 7D; *Cypraeovula capensis*, Figure 159). In some groups of cowries, the lower part of the shaft is characterized by a dark staining band near the base (internal bract) (Figure 6) (Troschel, 1863; Kay, 1960b). In *Lyncina lynx* (Figure 7A-C) the basal platform is smooth; in other cowries it bears denticles laterally as extensions of the corners (*Luria isabella*, Figure 147), medially on the shaft (*Cribrarula cribraria*, Figure 201), or attached to a "subtending bract" ("stützblättchen" of Troschel, 1863; Kay, 1957a) (*Erosaria* (*Paulonaria*) *caputserpentis*, Figure 6). The subtending bract does not stain with potassium permanganate or other commonly used histological stains.

Tooth separation and overlap within radular rows reflect the manner of attachment of the teeth to the radular membrane and/or interactions between teeth. In *Luria isabella* (Figure 147), *Talparia talpa* (Figure

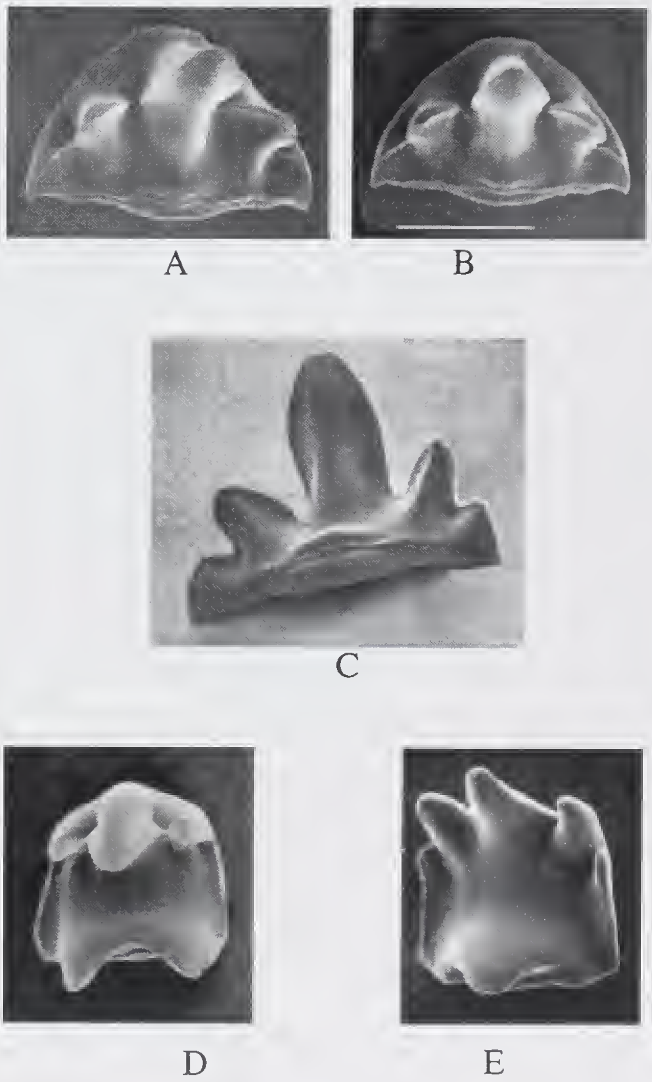

Figure 7A-E. Characteristic shape of the central tooth in three radular patterns. (A-C) central tooth of *Lyncina lynx* from three different directions [note the pendulous cusps] (D) central tooth of *Cypraea tigris* [note the massive cusps and basal denticles] (E) lateral tooth of *Erosaria caputserpentis* with medially projecting basal denticle.

177), and *T. exusta* (Figure 178), where the teeth are separated, each tooth is separately attached to the radular membrane. Where there is overlap, the marginal teeth especially are hinged or articulate with other marginal teeth in the row above or below as in *Mauritia maculifera* (Figure 113). Bandel (1984) pointed out such an arrangement in *Bistolida erythraeensis* (Figure 71): the marginal teeth are hinged at the base, and the outer marginal rests on the inner marginal, both fitting into the concave basal platform of the lateral tooth, with the apices resting below the cutting edge of the lateral. This arrangement is also noticeable in *Blasicrura burgessi* (Figure 65) and *B. rashleighana* (Figure 67). In *Monetaria annulus* (Figure 57) and *Erronea nebrites* (Figure 45) the marginal teeth, although independently attached to the radular membrane, fit into one another (Bandel, 1984). In *Lyncina lynx* (Figure 11), the inner marginal is attached along much of the width and only the outer marginal moves outward, fitting into the inner marginal and held in place by a strong basal swelling and raised outer anterior corner of the inner marginal (Bandel, 1984). In *Mauritia maculifera* (Figure 113) the marginal teeth clearly articulate with one another, the marginal in the lower row abutting that in the row above.

Each row of teeth on the radular ribbon usually repeats precisely the number and shape of the teeth in the rows in front of and behind it. There are instances, however, when radular rows are not precisely repeated, and the radular pattern is distinctly different from the norm. Figure 8A-B depicts an aberrant and a normal radula from specimens of *Erronea onyx* reported by Bradner (1991). The aberrant radula resembles those of *Talparia talpa* and *T. exusta* (Figures 177 and 178). F. Schilder (1963), and F. Schilder and M. Schilder (1966) figure several aberrant radulae, and Wilson and McComb (1967) describe a strange radula of *Zoila venusta* with four lateral teeth on one side. Several cases of sexual dimorphism are also documented (F. Schilder & M. Schilder, 1966; Schilder & Cernohorsky, 1965) in which the radular teeth in the male is larger or smaller than that of the female, depending on species.

Cowrie Classification and Radular Patterns

Traditionally, cowries have been classified primarily on the basis of conchological characters (Gray, 1824-1828; Melvill, 1888). In contrast, Troschel (1863), F. Schilder (1927, 1936), Thiele (1931), F. Schilder and M. Schilder (1938-1939), and Kay (1957a, 1960a, 1960b, 1961, 1963, 1981, 1985), included radular characters in their work on cowrie classification. Indeed, the radula was the basis for Troschel's (1863) system of gastropod classification, and he distinguished eight cowrie genera and subgenera utilizing characters of the radular teeth. In his initial revision of the Cypraeacea, F. Schilder (1927) provided descriptions, but did not illustrate the radular teeth, of more than 30 cowrie species and incorporated features of the radula in his arrangement of subfamilies, tribes and genera in subsequent revisions (F. Schilder, 1936; F. Schilder & M. Schilder, 1938-1939; M. Schilder & F. Schilder, 1971). Our studies confirm Schilder's (1927) assertion that the cowrie radula has been of prime importance in cowrie classification and provides a wealth of useful characters.

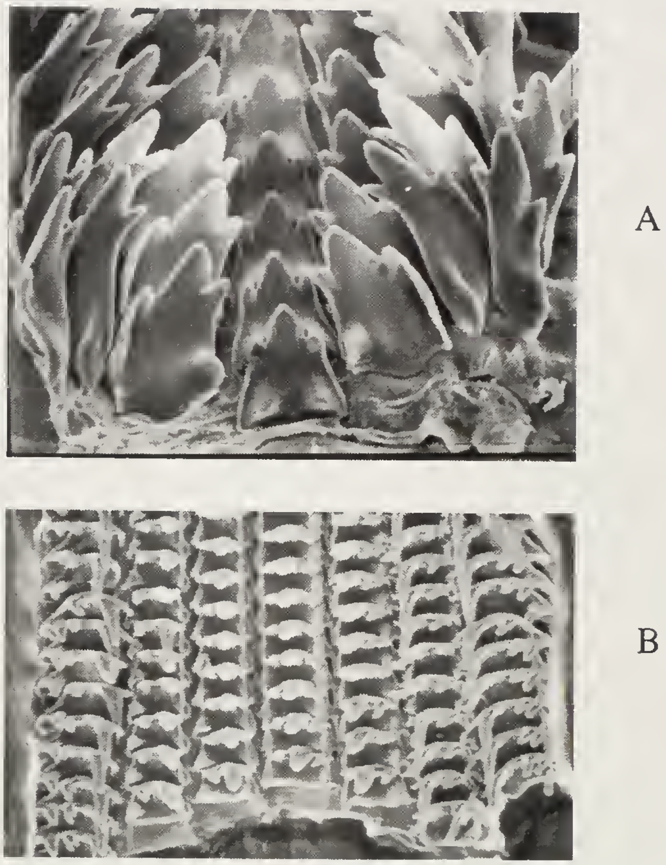

Figure 8 A-B. Example of normal vs. aberrant radula of *Erronea onyx*. (A) normal radula of *E. onyx* (B) aberrant radula of *E. onyx*, similar to radulae of *Talparia talpa* and *T. exusta*.

Most cowries appear to have stable patterns of tooth form, structure and arrangement. The central tooth of *Monetaria annulus*, for example, has been figured at least six times since Troschel's drawing in 1863 (Azuma, 1960b; Bandel, 1984; Kay 1957a; Soemodihardjo, 1965; Vayssière, 1923; Wu, 1987) and is arguably recognizable in all the illustrations. This stability of pattern permits identification of species figured in the literature. Vayssière's (1923) figures 158-161 illustrating radular teeth of "*Cypraea* sp.?" are clearly recognizable as those of *Luria lurida*. Azuma's (1960a) figure labelled *Cypraea schilderorum* does not fit the familiar tooth shape in species with which it is associated such as *Lyncina lynx* but rather is an illustration of the radula of a species of *Erosaria*.

In this study, stability of form permits recognition of 13 radular patterns which accommodate more than 200 cowrie species. Each pattern is named for the species which serves as the model for the pattern, and thus is a departure from the arrangement of Kay (1960b) which recognized four patterns by number. Selection of the model for each pattern was not consistent: In some instances the model species represents the type of the genus *(Lyncina)*; in others it represents the oldest of the generic names in a pattern *(Cypraea, Mauritia)*, the oldest species name in a group of species (*teres*), or it was selected simply as a matter of convenience *(Luria, Achatidea)*.

The patterns described were originally intended merely as a convenience to group like with like: central teeth with or without basal denticles, central teeth which are domelike, central teeth with five cusps rather than three, etc. The patterns, however, are remarkably consistent with M. Schilder and F. Schilder's (1971) generic arrangement. We have, therefore, utilized that arrangement with few changes (Table 1). In our 13 patterns, 18 of the 21 genera which include Recent cowrie species retain their integrity, representing either monogeneric patterns (for example the lynx pattern is comprised only of species in *Lyncina*) or included with other genera in a pattern (for example, the mauritiana pattern comprised of species in four genera). In each of two genera, a single species is aberrant: of the 16 species of *Palmadusta*, 15 fall into the cicercula pattern, one into the limacina pattern; in *Pustularia* five of the six species fall into the cicercula pattern, one into the erosa pattern. Only in *Blasicrura* is the genus fragmented, and the 15 species recognized by M. Schilder and F. Schilder (1971) are distributed among five of the 13 patterns.

The features of the radulae illustrated here comprise but one component of an extensive data set of shell features, mantle characters, reproductive structures, nervous system pattern, larval shells, and fossil history now being assembled as a monograph of cowrie systematics and phylogeny (Kay, in preparation).

PROTOCOL AND PROCEDURE

We have been conservative in our use of specific names, retaining traditionally used names such as *Erosaria labrolineata* (Gaskoin, 1849) rather than *E. flaveola* Linnaeus, 1758. But there are some changes in generic assignment: M. Schilder & F. Schilder's (1971) *Zonaria arabicula* is included in *Mauritia*; *Luria* which was synonymized with *Talparia* in Kay (1995) is here recognized as distinct; and Kilburn's (1974) *Nesiocypraea lisetae* is included in *Erronea (Adusta)*.

Unless otherwise indicated, data on mantle color and papillae, reproductive system and larval shells derive from the junior author's data set.

For purposes of dating the Tertiary fossil records we follow Kay (1990, 1996) who cited Shuto's (1976) correlations of Neogene formations of Southeast and South Asia for Pakistan and Indonesia; Darragh (1985) for Australia; Beu & Maxwell (1990) for New Zealand; Ladd (1977) for Pacific Islands; and Kollmann & Peel (1983) for Greenland. Groves (1994a, 1994b) is here cited for western American fossil records.

ILLUSTRATIONS OF COWRIE RADULAE.

Eight hundred, forty-one light microscope (OM) and scanning electron microscope (SEM) photographs of cowrie radula teeth comprise the bulk of this work. Line drawings adapted from F.A. Schilder's original drawings of 80 species are included to illustrate the similarity of characters within each of the radular patterns. The drawings, now in the Schilder Collection (SC), are supplemented by drawings from Troschel (1863), Vayssière (1923), Griffiths (pers. comm.), and Bandel (1984). Table 2 is an alphabetical list of the 202 cowrie species whose radulae are illustrated in this monograph, along with their genera and radular patterns. Figures 11-238 illustrate the radulae, ordered in 13 patterns, and described at the beginning of each pattern. Average radular and tooth dimensions are cited, with the designation n=xx referring to the number of specimens from which the data were obtained. Within each pattern, the radula of the model species is shown first and the remaining species are arranged alphabetically except where conchological similarities imply either synonymies or close relationships, in which case the species are placed contiguously irrespective of alphabet: for example, *Erosaria caputserpentis* next to *E. caputdraconis*,

Table 1.

Distribution of M. Schilder & F. Schilder's (1971) genera among 13 radular patterns.

[Differences from the Schilder and Schilder designations include: *Bernaya teulerei* as *Barycypraea*, *Mauritia* (*Leporicypraea*) *mappa* and *M.* (*L.*) *valentia* as *Cypraea*, *Zonaria arabicula* as *Mauritia*, *Tessellata tessellata* as *Luria*, and *Siphocypraea* (*Muracypraea*) *mus* as *Muracypraea*.]

Pattern	**Genus/Species**
Lynx	*Lyncina*
Erosa	*Erosaria* *Monetaria* *Pustularia (Ipsa) childreni* *Naria*
Teres	*Blasicrura teres* *Blasicrura burgessi* *Blasicrura latior* *Blasicrura rasheighana* *Blasicrura subteres*
Stolida	*Bistolida* *Ovatipsa*
Errones	*Erronea* *Blasicrura coxeni* *Blasicrura dayritiana* *Blasicrura luchuana* *Blasicrura quadrimaculata* *Notadusta*
Mauritiana	*Mauritia* *Macrocypraea* *Trona* *Zonaria*
Tigris	*Cypraea* *Muracypraea* *Umbilia* *Zoila*
Isabella	*Luria*
Achatidea	*Schilderia* *Barycypraea* *Cypraeovula* *Nesiocypraea*
Talpa	*Talparia*
Testudinaria	*Chelycypraea*
Limacina	*Staphylaea* *Nucleolaria* *Blasicrura goodalli* *Blasicrura pallidula* *Blasicrura summersi* *Palmadusta yaloka*
Cicercula	*Pustularia* *Blasicrura interrupta* *Cribrarula* *Notocypraea* *Palmadusta* *Propustularia*

Nucleolaria granulata next to *N. cassiaui*, *Luria isabella* next to *L. isabellamexicana*, *Lyncina schilderorum* next to *L. sulcidentata*. Captions on the photos identify the species. Appendix I identifies the SEM stub and OM slide for each specimen illustrated. Appendix II shows available information on dimensions of shells and radulae. All available material, including additional SEM and OM photos of many of the species, stereo SEM photos of individual teeth of 23 species, as well as all available notebooks, residual animals and radulae, shells, SEM stubs and OM slides are in the collections of the Zoology Department, University of Hawaii, Manoa, and will later be deposited in The Natural History Museum, London.

Most cypraeid radulae reported in the literature have been examined by optical microscopy and figured in either drawings or photographs. Except for publications of Bradner (1979, 1983, 1984, 1985, 1987a, 1987b, 1989, 1991, 1993a, 1993b) and Kay (1957b, 1960a, 1960b, 1961, 1963, 1979, 1981, 1985), only 19 species have previously been figured in SEM photos, and nine species in OM photos. Approximately 110 species have been figured in line drawings. Appendix III is a bibliography of publications that depict cowrie radulae.

All types of radula tooth illustration have their problems. In most species the teeth are too small and curved to permit sharp photos of tooth shape by OM; and drawings may result in, often unconscious, bias. Scale is also a problem. SEM photographs show external details of teeth but do not reveal internal structure. In SEM photographs, apparent tooth shape in a single view can be misleading, as for example in the case of *Monetaria annulus* (Figure 57), where in the SEM view (B), the blades of the lateral and marginal teeth appear to have rounded paddle-shaped tips. Because tooth shape changes with tooth maturity (Figure 9), the SEM photos in this monograph are of sections taken from the central third of the radular ribbon insofar as was possible.

In almost all cases the photos presented consist of three SEM and one OM view from one or more specimens representing a species. Cowrie radulae are depicted here in the traditional manner, as flexible, flat, toothed ribbons, with the end that scrapes the substrate pointing toward the bottom of the figure (Figure 1A). SEM photos of each specimen were taken from three directions, as shown in Figure 10, to facilitate visualizing tooth shape. Camera positions were: (A) the familiar optical photomicrograph view directly above the specimen (stage at O°), (B) looking along the ribbon with the stage tilted at 60°, (C) stage at the same tilt angle of 60° but rotated 45^0 to view the ribbon obliquely. "150 micron" scale bars are shown on views A and B. Details of materials and methods are described in a separate paper (Bradner & Kay, 1995).

Among the following illustrations we note several inconsistencies that need further study: In *Staphylaea staphylaea* (Figures 193, 194) and in species associated with *Blasicrura teres* (Figures 63-68), two different patterns of marginal teeth are identifiable, one with slender sickle-like marginals, the other with short, stout marginals. Any one of three possibilities could account for the different patterns: 1) the two patterns represent examples of sexual dimorphism, 2) there is a complex group of species with unnamed species among them, and 3) the specimens were initially incorrectly identified.

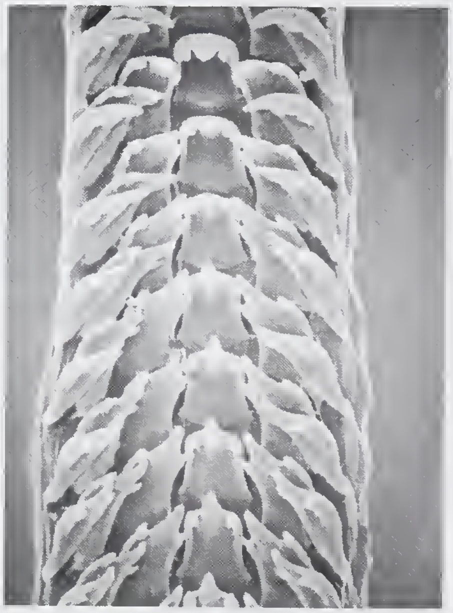

Figure 9. Change in tooth shape with maturity (*Blasicrura luchuana*). The most mature teeth are at the top of the figure.

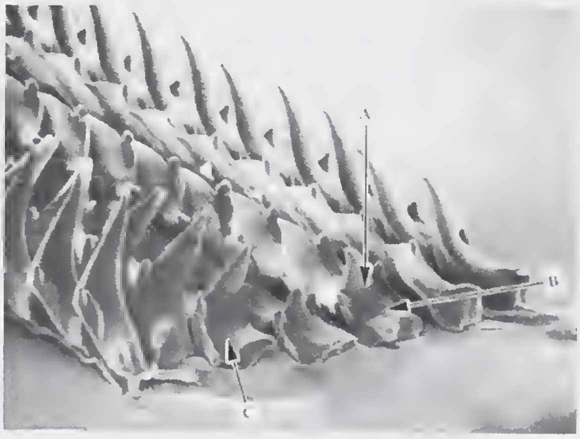

Figure 10. Standardized directions for SEM photos (*Erosaria cernica*).

Table 2.

Alphabetical list of cypraeid species whose radulae are illustrated herein with genera and radular patterns

Species	**Genus**	**Pattern**
achatidea (Sowerby, 1837)	*Schilderia*	achatidea
aequinoctialis F. Schilder, 1933	*Zonaria*	mauritiana
albuginosa (Gray, 1825)	*Erosaria* s.s.	erosa
alfredensis (F. Schilder & M. Schilder, 1929)	*Cypraeovula*	achatidea
algoensis (Gray, 1825)	*Cypraeovula*	achatidea
alisonae (Burgess, 1983)	*Blasicrura*	teres
angustata (Gmelin, 1791)	*Notocypraea*	cicercula
annettae (Dall, 1909)	*Zonaria*	mauritiana
annulus (Linnaeus, 1758)	*Monetaria (Ornamentaria)*	erosa
arabica (Linnaeus, 1758)	*Mauritia*	mauritiana
arabicula (Lamarck, 1810)	*Mauritia*	mauritiana
argus (Linnaeus, 1758)	*Lyncina*	lynx
armeniaca (Verco, 1912)	*Umbilia*	tigris
artuffeli (Jousseaume, 1876)	*Palmadusta* s.s.	cicercula
asellus (Linnaeus, 1758)	*Palmadusta* s.s.	cicercula
astaryi F. Schilder, 1971	*Cribrarula* s.s.	cicercula
aurantium (Gmelin, 1791)	*Lyncina*	lynx
barclayi (Reeve, 1857)	*Erronea (Adusta)*	errones
beckii (Gaskoin, 1836)	*Erosaria (Paulonaria)*	erosa
bicolor (Gaskoin, 1849)	*Notocypraea*	cicercula
bistrinotata F. Schilder & M. Schilder, 1937	*Pustularia* s.s.	cicercula
boivinii (Kiener, 1843)	*Erosaria* s.s.	erosa
bouteti (Burgess & Arnette, 1981)	*Lyncina*	lynx
bregeriana (Crosse, 1868)	*Erronea (Adusta)*	errones
broderipii (Sowerby, 1832)	*Lyncina*	lynx
burgessi (Kay, 1981)	*Blasicrura*	teres
camelopardalis (Perry, 1811)	*Lyncina*	lynx

capensis (Gray, 1828)	*Cypraeovula*	achatidea
caputdraconis (Melvill, 1888)	*Erosaria (Ravitrona)*	erosa
caputserpentis (Linnaeus, 1758)	*Erosaria (Ravitrona)*	erosa
carneola (Linnaeus, 1758)	*Lyncina*	lynx
cassiaui (Burgess, 1965)	*Nucleolaria*	limacina
catholicorum F. Schilder & M. Schilder, 1938	*Cribrarula*	cicercula
caurica (Linnaeus, 1758)	*Erronea* s.s.	errones
cernica (Sowerby, 1870)	*Erosaria* s.s.	erosa
cervinetta (Kiener, 1843)	*Macrocypraea*	mauritiana
cervus (Linnaeus, 1771)	*Macrocypraea*	mauritiana
childreni (Gray, 1825)	*Pustularia (Ipsa)*	erosa
chinensis (Gmelin, 1791)	*Ovatipsa*	stolida
cicercula (Linnaeus, 1758)	*Pustularia*	cicercula
cinerea (Gmelin, 1791)	*Luria*	isabella
citrina (Gray, 1825)	*Erosaria* s.s.	erosa
clandestina (Linnaeus, 1767)	*Palmadusta* s.s.	cicercula
coloba (Melvill, 1888)	*Ovatipsa*	stolida
comptonii (Gray, 1847)	*Notocypraea*	cicercula
connelli (Liltved, 1983)	*Cypraeovula*	achatidea
contaminata (Sowerby, 1832)	*Palmadusta* s.s.	cicercula
coronata (F. Schilder, 1930)	*Cypraeovula*	achatidea
coxeni (Cox, 1873)	*Blasicrura*	errones
cribellum (Gaskoin, 1849)	*Cribrarula*	cicercula
cribraria (Linnaeus, 1758)	*Cribrarula*	cicercula
cruickshanki (Kilburn, 1972)	*Cypraeovula*	achatidea
cumingii (Sowerby, 1832)	*Cribrarula*	cicercula
cylindrica (Born, 1778)	*Erronea* s.s.	errones
dayritiana (Cate, 1963)	*Blasicrura*	errones
decipiens (Smith, 1880)	*Zoila*	tigris
declivis (Sowerby, 1870)	*Notocypraea*	cicercula
depressa (Gray, 1824)	*Mauritia*	mauritiana
dillwyni (F. Schilder, 1922)	*Erosaria (Paulonaria)*	erosa
diluculum (Reeve, 1845)	*Palmadusta* s.s.	cicercula

eburnea (Barnes, 1824)	*Erosaria s.s.*	erosa
edentula (Gray, 1825)	*Cypraeovula*	achatidea
eglantina (Duclos, 1833)	*Mauritia*	mauritiana
englerti (Summers & Burgess, 1965)	*Erosaria s.s.*	erosa
erosa (Linnaeus, 1758)	*Erosaria s.s.*	erosa
errones (Linnaeus, 1758)	*Erronea s.s.*	errones
erythraeensis (Sowerby, 1837)	*Bistolida*	stolida
esontropia (Duclos, 1833)	*Cribrarula*	cicercula
exusta (Sowerby, 1832)	*Talparia*	talpa
fallax (Smith, 1881)	*Cribrarula*	cicercula
felina (Gmelin, 1791)	*Erronea s.s.*	errones
fimbriata (Gmelin, 1791)	*Palmadusta (Purpuradusta)*	cicercula
friendii (Gray, 1831)	*Zoila*	tigris
fultoni (Sowerby, 1903)	*Barycypraea*	achatidea
fuscodentata (Gray, 1825)	*Cypraeovula*	achatidea
fuscorubra (Shaw, 1909)	*Cypraeovula*	achatidea
gambiensis (Shaw, 1909)	*Zonaria*	mauritiana
gangranosa (Dillwyn, 1817)	*Erosaria s.s.*	erosa
gaskoini (Reeve, 1846)	*Cribrarula*	cicercula
globulus (Linnaeus, 1758)	*Pustularia s.s.*	cicercula
gondwanalandensis (Burgess, 1970)	*Cypraeovula*	achatidea
goodallii (Sowerby, 1832)	*Blasicrura*	limacina
gracilis (Gaskoin, 1849)	*Palmadusta (Purpuradusta)*	cicercula
granulata (Pease, 1862)	*Nucleolaria*	limacina
grayana F. Schilder, 1930	*Mauritia*	mauritiana
guttata (Gmelin, 1791)	*Erosaria s.s.*	erosa
hammondae (Iredale, 1939)	*Palmadusta (Purpuradusta)*	cicercula
helvola (Linnaeus, 1758)	*Erosaria*	erosa
hesitata (Iredale, 1916)	*Umbilia*	tigris
hirasei (Roberts, 1913)	*Nesiocypraea*	achatidea
hirundo (Linnaeus, 1758)	*Bistolida*	stolida
histrio (Gmelin, 1791)	*Mauritia*	mauritiana
hungerfordi (Sowerby, 1888)	*Erronea (Adusta)*	errones

interrupta (Gray, 1824)	*Blasicrura*	cicercula
irrorata (Gray, 1828)	*Naria*	erosa
isabella (Linnaeus, 1758)	*Luria*	isabella
isabellamexicana (Stearns,1893)	*Luria*	isabella
iutsui Shikama, 1974	*Cypraeovula*	achatidea
jeaniana Cate, 1968	*Zoila*	tigris
katsuae (Kuroda, 1960)	*Notadusta*	errones
kieneri (Hidalgo, 1906)	*Bistolida*	stolida
kingae (Rehder & Wilson, 1975)	*Erosaria s.s.*	erosa
kuroharai (Kuroda & Habe, 1961)	*Lyncina*	lynx
labrolineata (Gaskoin, 1849)	*Erosaria s.s.*	erosa
lamarckii (Gray, 1825)	*Erosaria s.s.*	erosa
langfordi (Kuroda, 1938)	*Nesiocypraea*	achatidea
latior (Melvill, 1888)	*Blasicrura*	teres
lentiginosa (Gray, 1825)	*Palmadusta s.s.*	cicercula
leucodon (Broderip, 1828)	*Lyncina*	lynx
leviathan F. Schilder & M. Schilder, 1937	*Lyncina*	lynx
limacina (Lamarck, 1810)	*Staphylaea*	limacina
lisetae (Kilburn, 1975)	*Erronea (Adusta)*	errones
luchuana (Kuroda, 1960)	*Blasicrura*	errones
lurida (Linnaeus, 1758)	*Luria*	isabella
lutea (Gmelin, 1791)	*Palmadusta s.s.*	cicercula
lynx (Linnaeus, 1758)	*Lyncina*	lynx
macandrewi (Sowerby, 1870)	*Erosaria (Paulonaria)*	erosa
maculifera F. Schilder, 1932	*Mauritia*	mauritiana
mappa Linnaeus, 1758	*Cypraea*	tigris
margarita (Dillwyn, 1817)	*Pustularia*	cicercula
marginalis (Dillwyn, 1827)	*Erosaria s.s.*	erosa
marginata (Gaskoin, 1849)	*Zoila*	tigris
mariae F. Schilder, 1927	*Pustularia (Annepona)*	cicercula
martini (Schepman, 1907)	*Notadusta*	errones
mauiensis (Burgess, 1967)	*Pustularia*	cicercula
mauritiana (Linnaeus, 1758)	*Mauritia*	mauritiana

mayi (Beddome, 1898)	*Notocypraea*	cicercula
microdon (Gray, 1828)	*Palmadusta* (*Purpuradusta*)	cicercula
midwayensis Azuma & Kurohara, 1967	*Nesiocypraea*	achatidea
mikeharti Lorenz, 1985	*Cypraeovula*	achatidea
miliaris (Gmelin, 1791)	*Erosaria* s.s.	erosa
minoridens (Melvill, 1901)	*Palmadusta* (*Purpuradusta*)	cicercula
moneta (Linnaeus, 1758)	*Monetaria*	erosa
mus (Linnaeus, 1758)	*Muracypraea*	tigris
nebrites (Melvill, 1888)	*Erosaria*	erosa
nigropunctata (Gray, 1828)	*Zonaria* (*Pseudozonaria*)	mauritiana
nivosa (Broderip, 1827)	*Lyncina*	lynx
nucleus (Linnaeus, 1758)	*Nucleolaria*	limacina
obvelata (Lamarck, 1810)	*Monetaria* (*Ornamentaria*)	erosa
ocellata (Linnaeus, 1758)	*Erosaria* s.s.	erosa
onyx (Linnaeus, 1758)	*Erronea (Adusta)*	errones
ovum (Gmelin, 1791)	*Erronea* s.s.	errones
owenii (Sowerby, 1837)	*Bistolida*	stolida
pallida (Gray, 1824)	*Erronea (Adusta)*	errones
pallidula (Gaskoin, 1849)	*Blasicrura*	limacina
pantherina [Lightfoot, 1786]	*Cypraea*	tigris
petitiana (Crosse, 1872)	*Zonaria*	mauritiana
picta (Gray, 1824)	*Zonaria*	mauritiana
piperita (Gray, 1825)	*Notocypraea*	cicercula
poraria (Linnaeus, 1758)	*Erosaria*	erosa
propinqua (Garrett, 1879)	*Lyncina*	lynx
pulchella (Swainson, 1823)	*Erronea (Adusta)*	errones
pulchra (Gray, 1824)	*Luria*	isabella
pulicaria (Reeve, 1846)	*Notocypraea*	cicercula
punctata (Linnaeus, 1771)	*Notadusta*	errones
pyriformis (Gray, 1824)	*Erronea*	errones
pyrum (Gmelin, 1791)	*Zonaria*	mauritiana
quadrimaculata (Gray, 1824)	*Blasicrura*	errones
rabaulensis F. Schilder, 1964	*Notadusta*	errones

rashleighana (Melvill, 1888)	*Blasicrura*	teres
reevei (Sowerby, 1832)	*Lyncina*	lynx
robertsi (Hidalgo, 1906)	*Zonaria*	mauritiana
rosselli Cotton, 1948	*Zoila*	tigris
sakuraii (Habe, 1970)	*Nesiocypraea*	achatidea
sanguinolenta (Gmelin, 1791)	*Zonaria*	mauritiana
saulae (Gaskoin, 1843)	*Palmadusta* s.s.	cicercula
schilderorum (Iredale, 1939)	*Lyncina*	lynx
scurra (Gmelin, 1791)	*Mauritia*	mauritiana
semiplota (Mighels, 1845)	*Staphylaea*	limacina
serrulifera F. Schilder & M. Schilder, 1938	*Palmadusta (Purpuradusta)*	cicercula
spadicea (Swainson, 1823)	*Zonaria (Neobernaya)*	mauritiana
spurca (Linnaeus, 1758)	*Erosaria* s.s.	erosa
staphylaea (Linnaeus, 1758)	*Staphylaea*	limacina
stercoraria (Linnaeus, 1758)	*Trona*	mauritiana
stolida (Linnaeus, 1758)	*Bistolida*	stolida
subteres (Weinkauff, 1881)	*Blasicrura*	teres
subviridis (Reeve, 1835)	*Erronea (Adusta)*	errones
sulcidentata (Gray, 1824)	*Lyncina*	lynx
summersi (F. Schilder, 1958)	*Blasicrura*	limacina
surinamensis (Perry, 1811)	*Propustularia*	cicercula
talpa (Linnaeus, 1758)	*Talparia*	talpa
teramachii (Kuroda, 1938)	*Nesiocypraea*	achatidea
teres (Gmelin, 1791)	*Blasicrura*	teres
tessellata (Swainson, 1822)	*Luria*	isabella
testudinaria (Linnaeus, 1758)	*Chelycypraea*	testudinaria
teulerei (Cazanavette, 1846)	*Barycypraea*	achatidea
thomasi (Crosse, 1865)	*Erosaria (Paulonaria)*	erosa
tigris Linnaeus, 1758	*Cypraea*	tigris
trenberthae (Trenberth, 1961)	*Notocypraea*	cicercula
turdus (Lamarck, 1810)	*Erosaria* s.s.	erosa
ursellus (Gmelin, 1791)	*Bistolida*	stolida
valentia Perry, 1811	*Cypraea*	tigris

ventriculus (Lamarck, 1810)	*Lyncina*	lynx
venusta (Sowerby, 1846)	*Zoila*	tigris
vitellus (Linnaeus, 1758)	*Lyncina*	lynx
vredenburgi F. Schilder, 1927	*Erronea (Adusta)*	errones
walkeri (Sowerby, 1832)	*Erronea (Adusta)*	errones
xanthodon (Sowerby, 1832)	*Erronea (Adusta)*	errones
yaloka Steadman & Cotton, 1943	*Palmadusta* s.s.	limacina
zebra (Linnaeus, 1758)	*Macrocypraea*	mauritiana
ziczac (Linnaeus, 1758)	*Palmadusta*	cicercula
zonaria (Gmelin, 1791)	*Zonaria*	mauritiana

The Lynx Pattern (Figures 7A-7C, 11-29).
Model species: *Lyncina lynx* (Linnaeus, 1758).

Species: *Lyncina argus* (Linnaeus, 1758); *L. aurantium* (Gmelin, 1791); *L. bouteti* (Burgess & Arnette, 1981); *L. broderipii* (Sowerby, 1832); *L. camelopardalis* (Perry, 1811); *L. carneola* (Linnaeus, 1758); *L. kuroharai* (Kuroda & Habe, 1961); *L. leucodon* (Broderip, 1828); *L. leviathan* F. Schilder & M. Schilder, 1937; *L. lynx* (Linnaeus, 1758); *L. nivosa* (Broderip, 1827); *L. propinqua* (Garrett, 1879); *L. reevei* (Sowerby, 1832); *L. schilderorum* (Iredale, 1939); *L. sulcidentata* (Gray, 1824); *L. ventriculus* (Lamarck, 1810); *L. vitellus* (Linnaeus, 1758).

The defining features of this radular pattern are the heavily chitinized teeth, among which the domelike central tooth is especially noticeable. In 60 percent of the specimens, the central tooth is in the 100-150 micron range (mean dimensions 129x199 microns; n=45) and is wider than it is long (mean length/width ratio 0.71; n=45). The cusps are deeply excavated, and the basal margin is gently curved. There are no internal bracts, subtending bracts or denticles. The lateral teeth are rectangular, wider than the central tooth, each with a strong, medially projecting basal denticle. The inner marginal is wider than the outer marginal in several species. The base of the outer marginal is enlarged in some species (for example *L. argus, L. broderipii*, and *L. carneola*).

Central tooth dimensions 60x80 to 305x430 microns (n=45).
No. of radular rows: 100 to 305 (n=35).
No. of radular rows per mm radula: 4.0 to 15.6 (n=28).

This distinctive radular pattern occurs in all the species referred to the genus *Lyncina* Troschel, 1863, by M. Schilder & F. Schilder (1971). Troschel characterized *Lyncina* by the half-circle shaped central tooth without distinct basal structures. The species form a seemingly cohesive group in the Indo-West Pacific, distinguished by cylindrical to pyriform shells with a broad, ribbed fossula; dark, gray-brown mantle with "shaving brush" papillae; and a bursa copulatrix in the females. All species for which the protoconch is known have a planktonic larval stage. Fossils of *Lyncina* are known from the early Miocene of Indonesia.

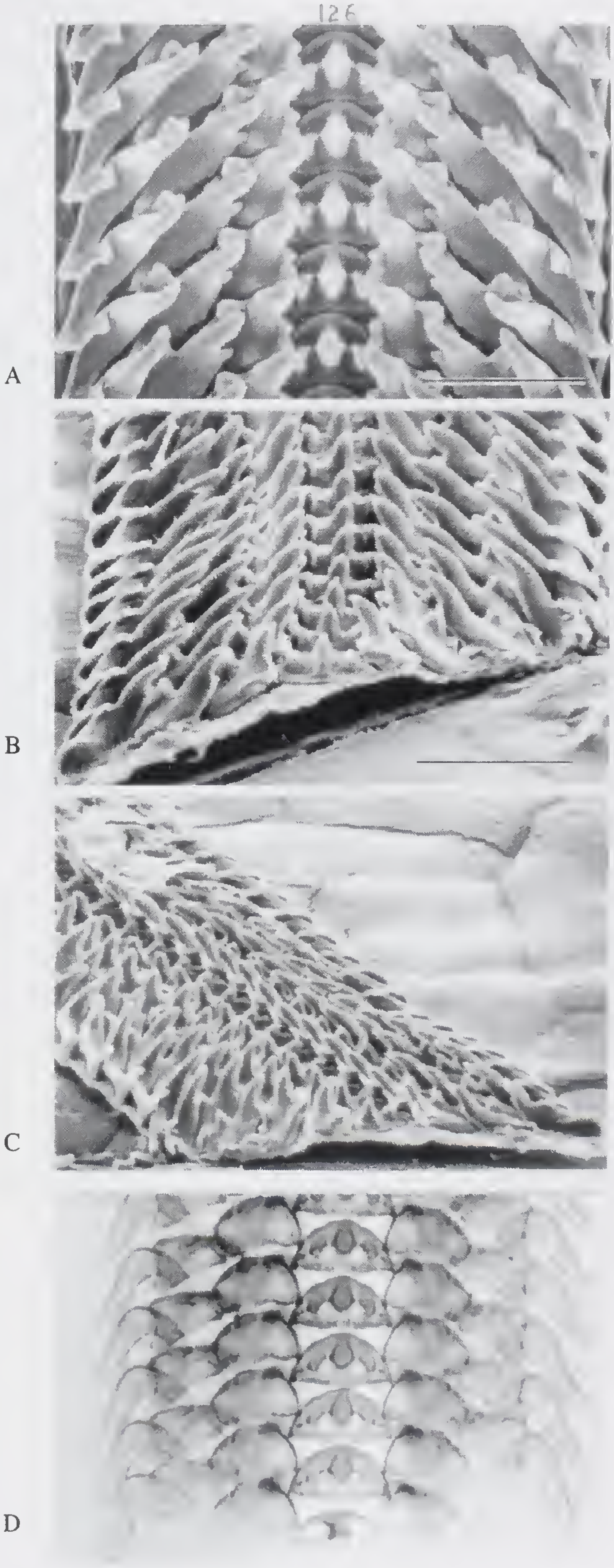

Figure 11. *Lyncina lynx*

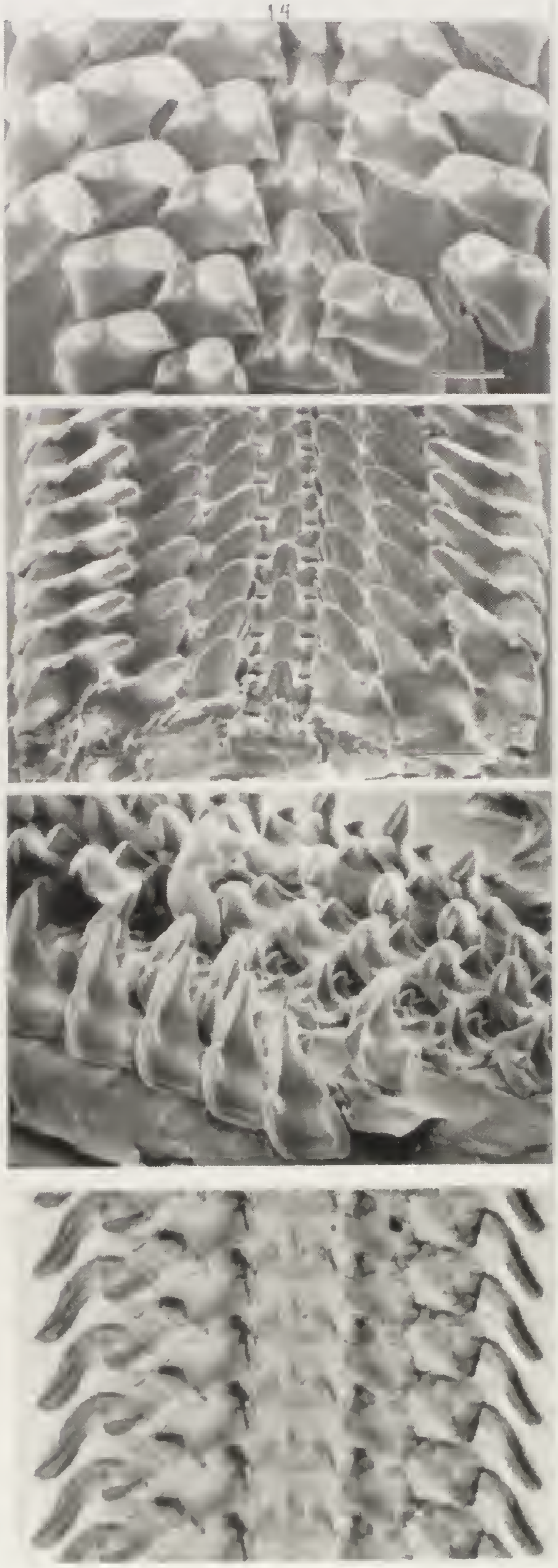

Figure 12. *Lyncina argus*

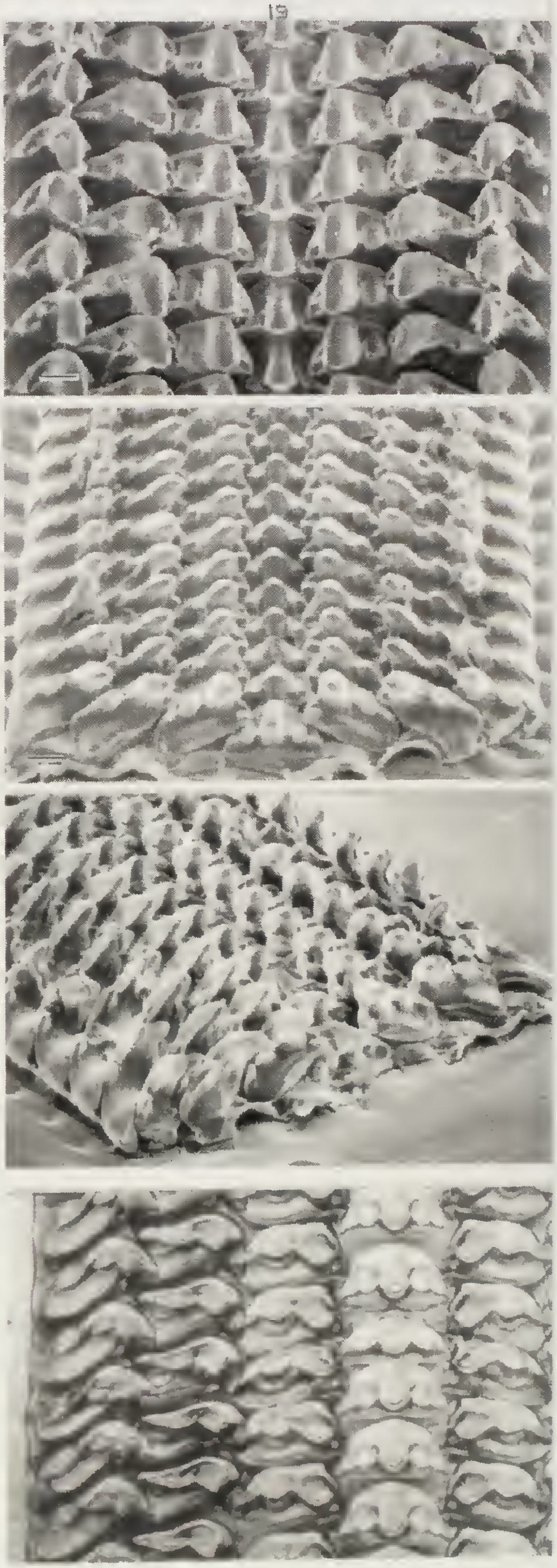

Figure 13. *Lyncina aurantium*

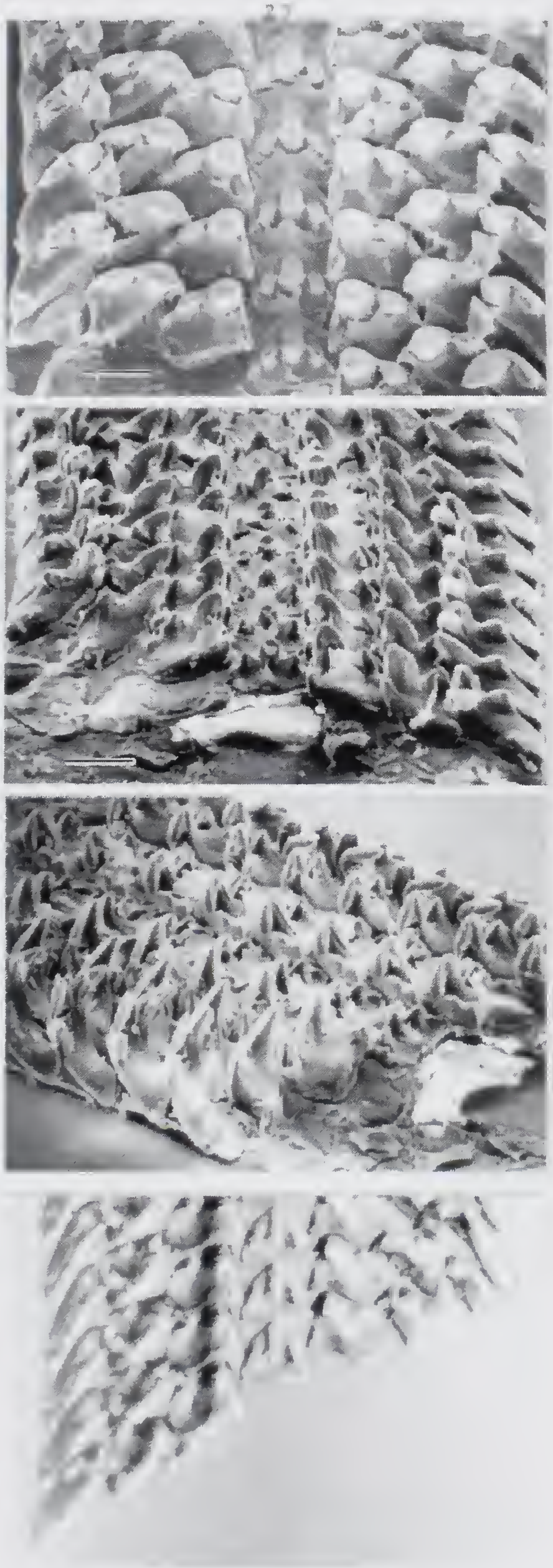

Figure 14. *Lyncina bouteti*

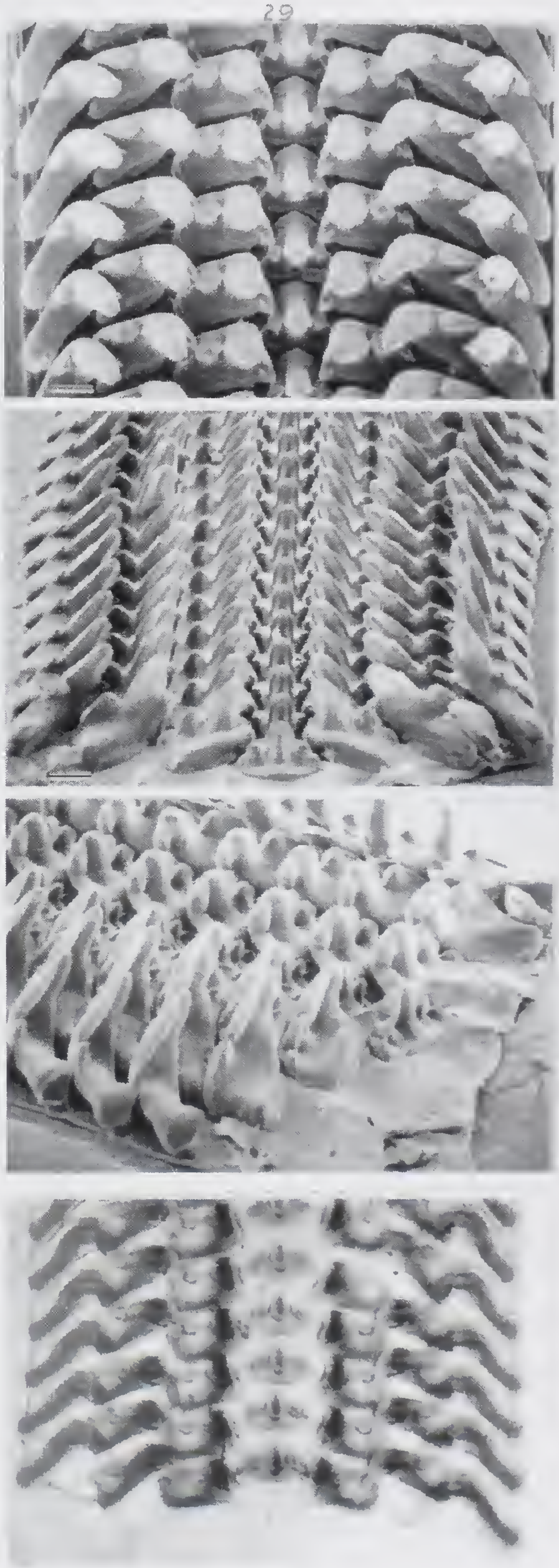

Figure 15. *Lyncina broderipii*

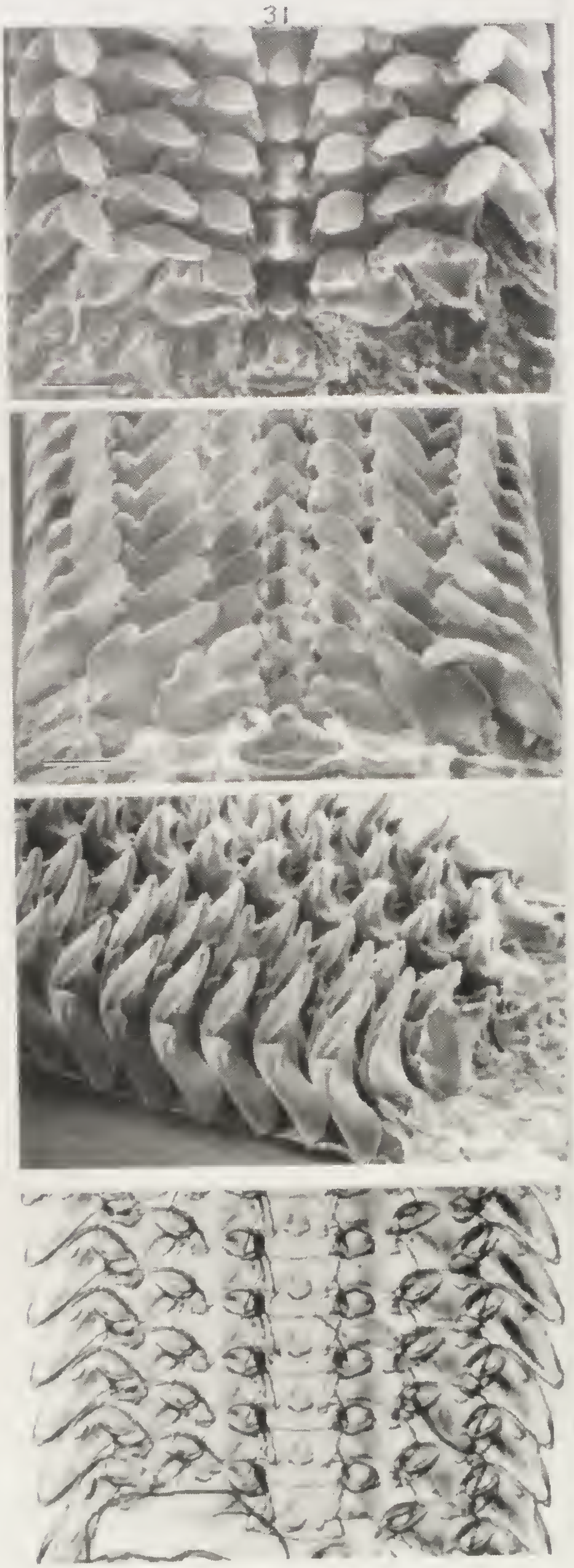

Figure 16. *Lyncina camelopardalis*

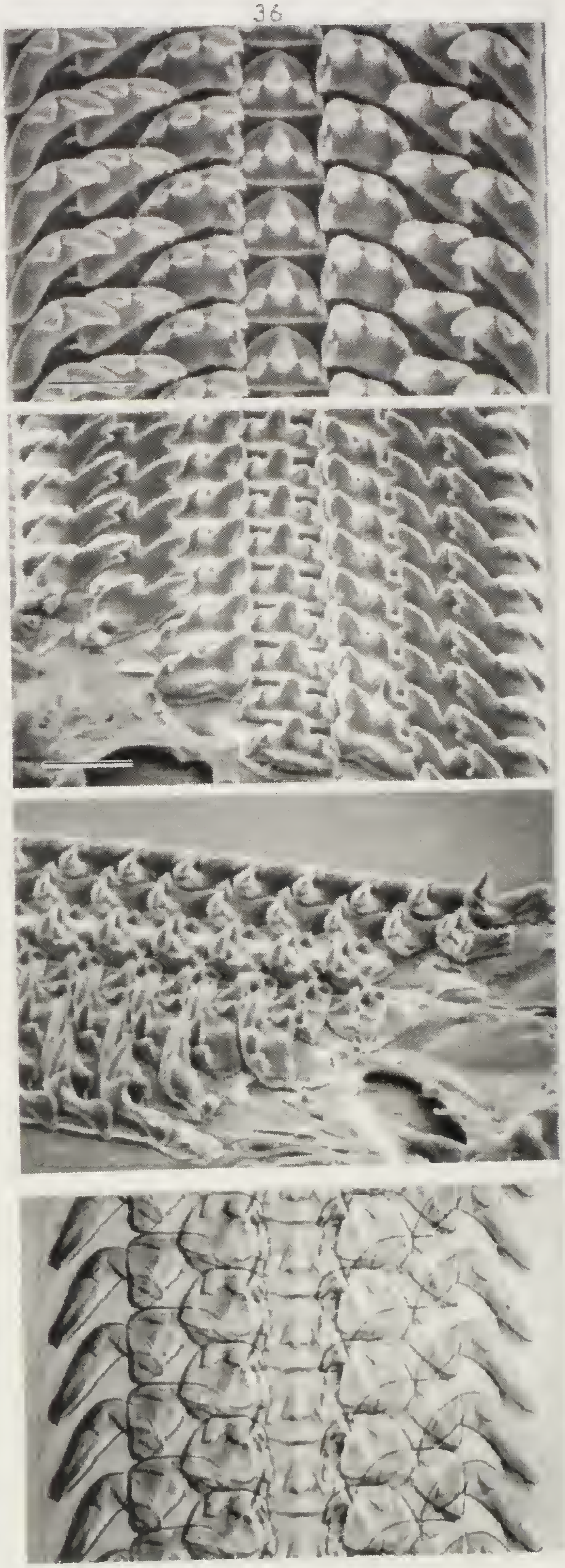

Figure 17. *Lyncina carneola*

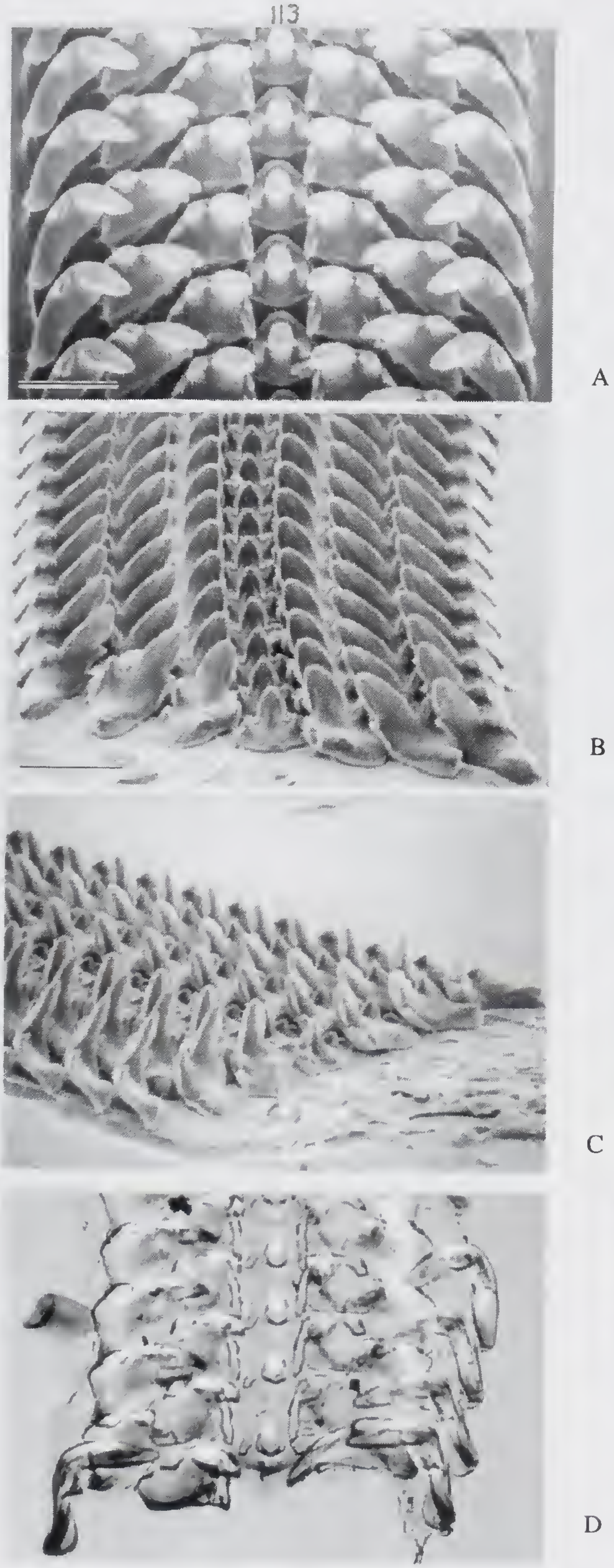

Figure 18. *Lyncina kuroharai*

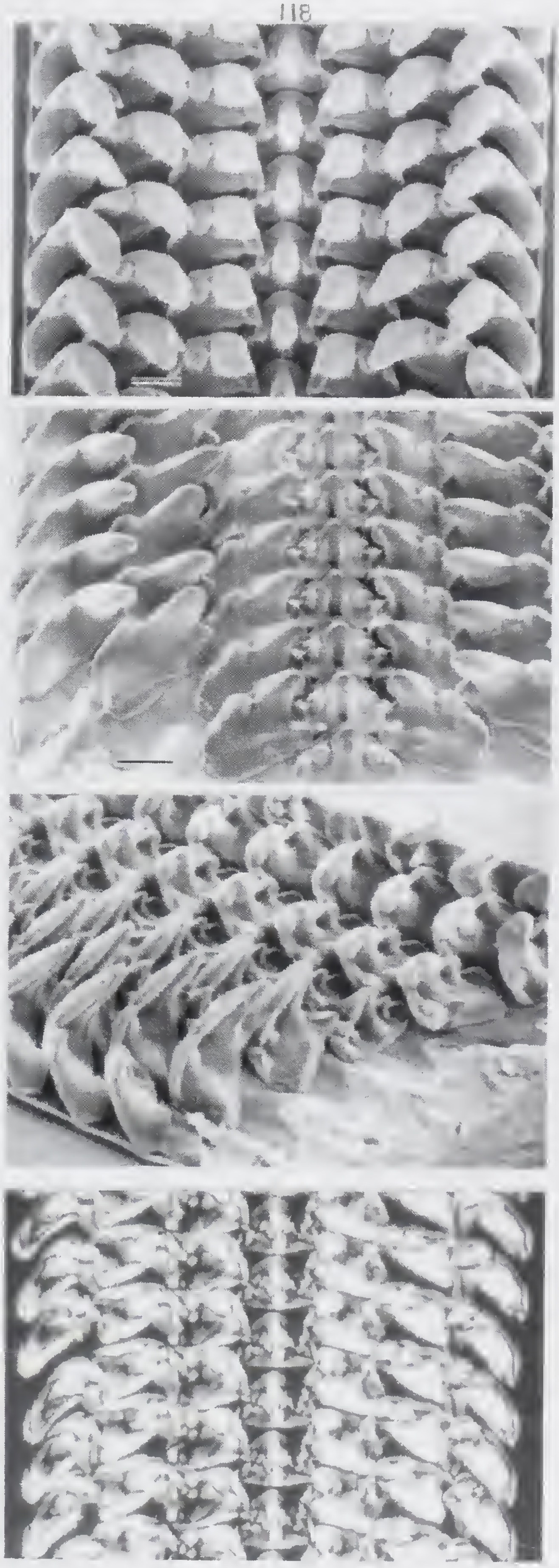

Figure 19. *Lyncina leucodon*

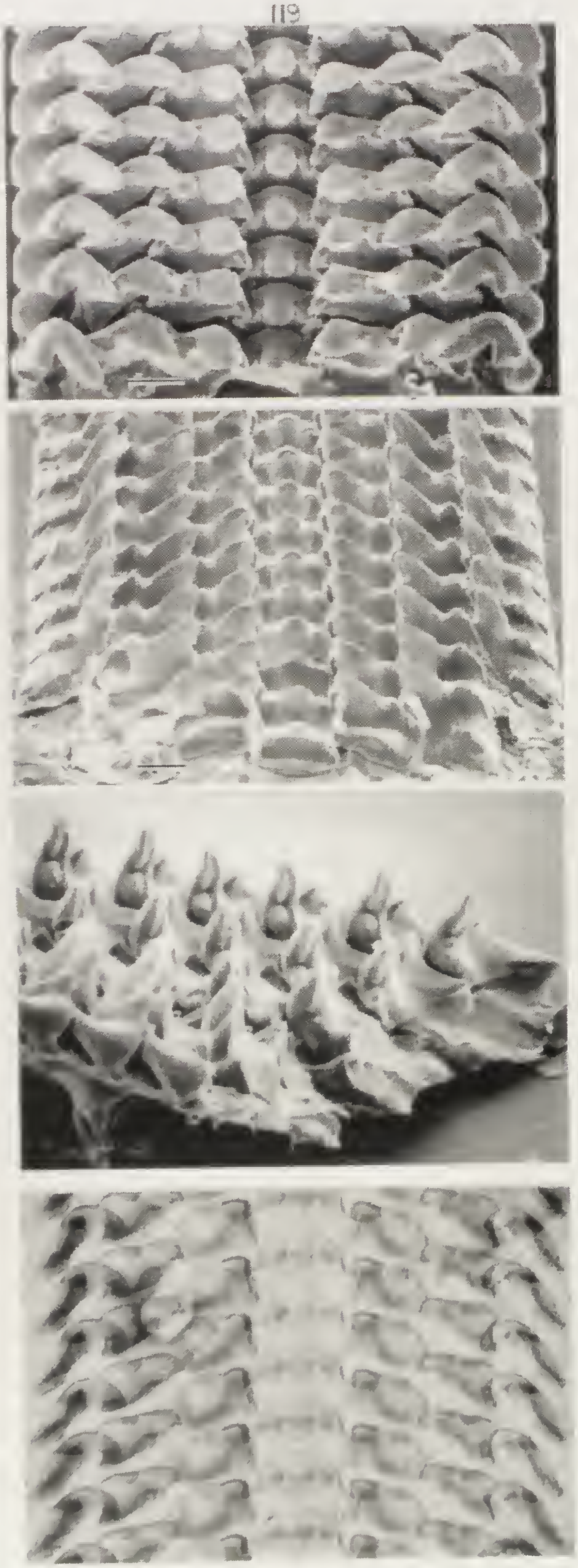

Figure 20. *Lyncina leviathan*

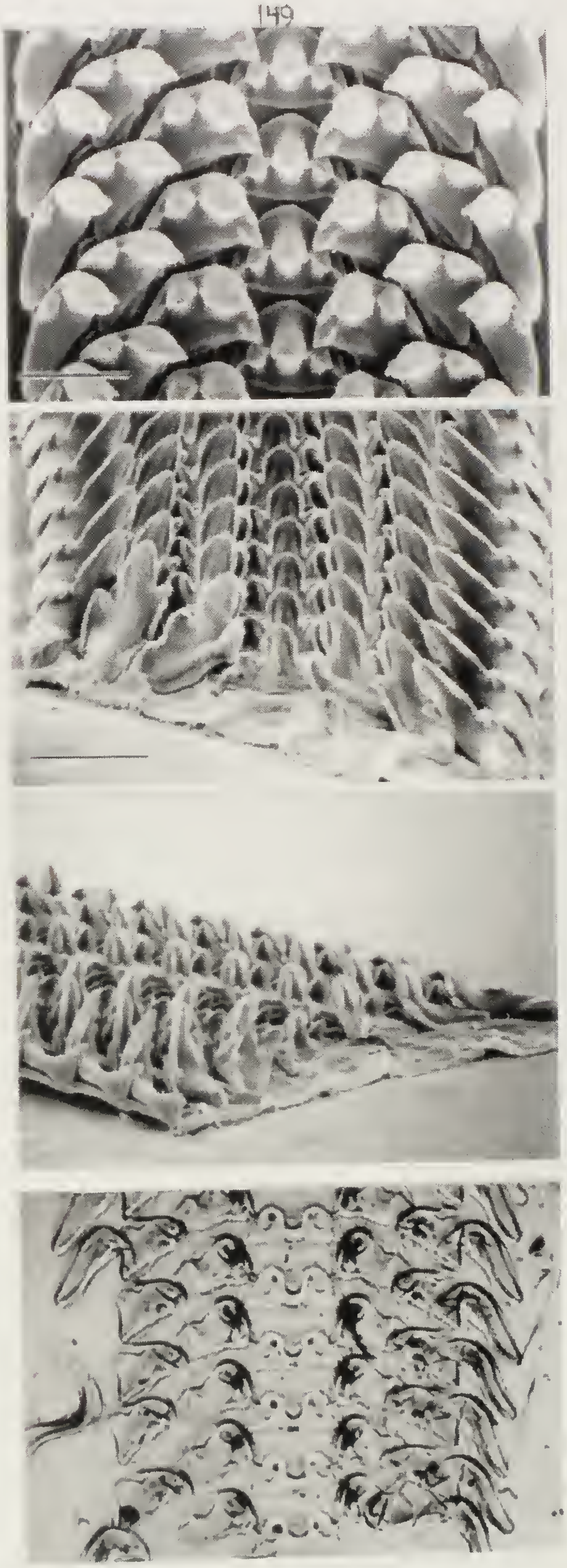

Figure 21. *Lyncina nivosa*

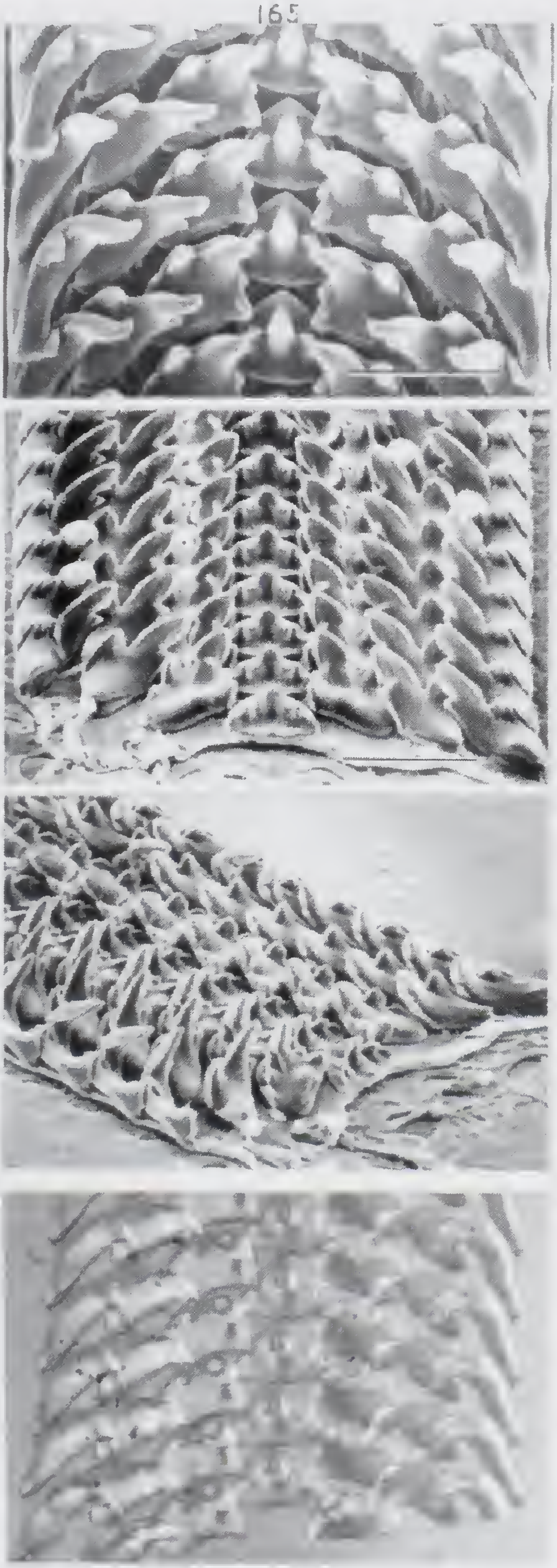

Figure 22. *Lyncina propinqua*

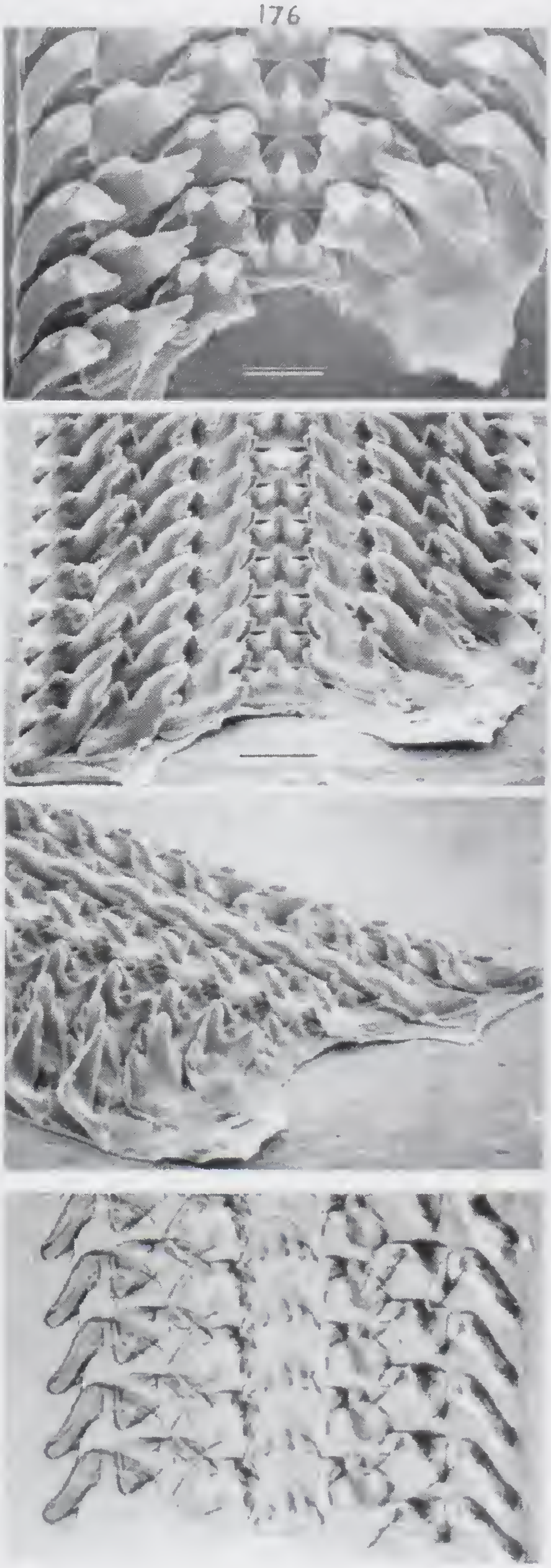

Figure 23. *Lyncina reevei*

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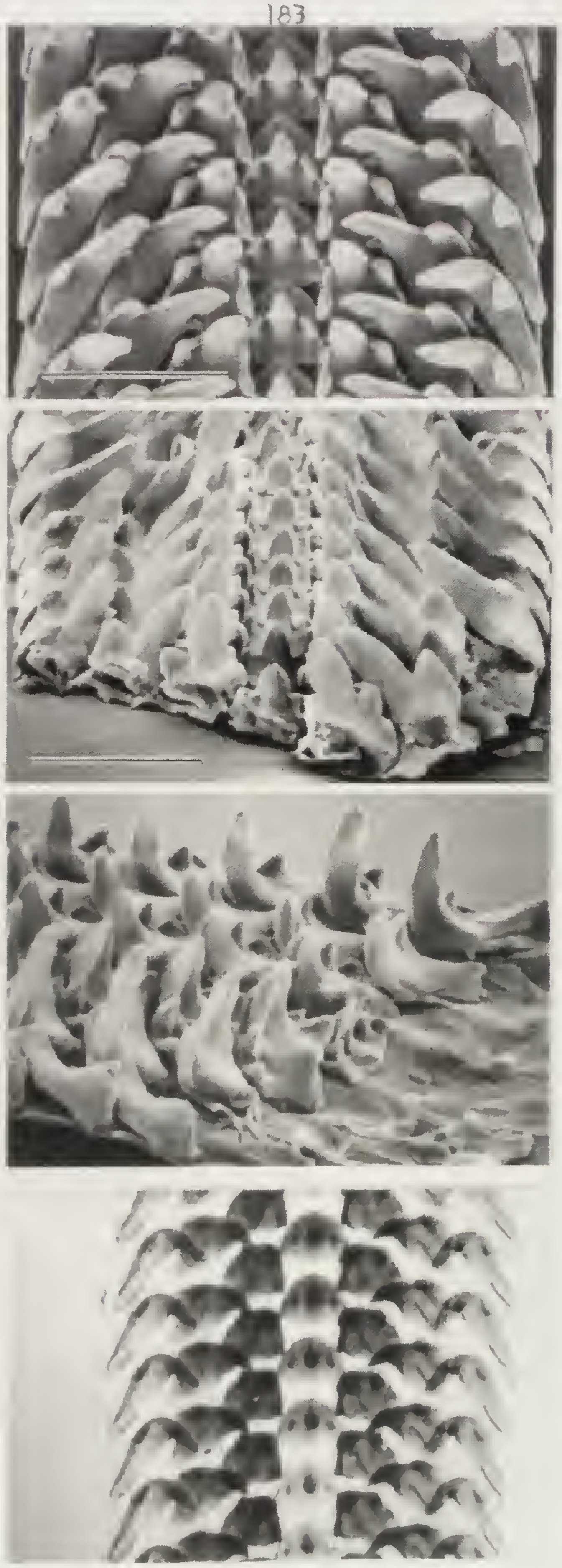

Figure 24. *Lyncina schilderorum*

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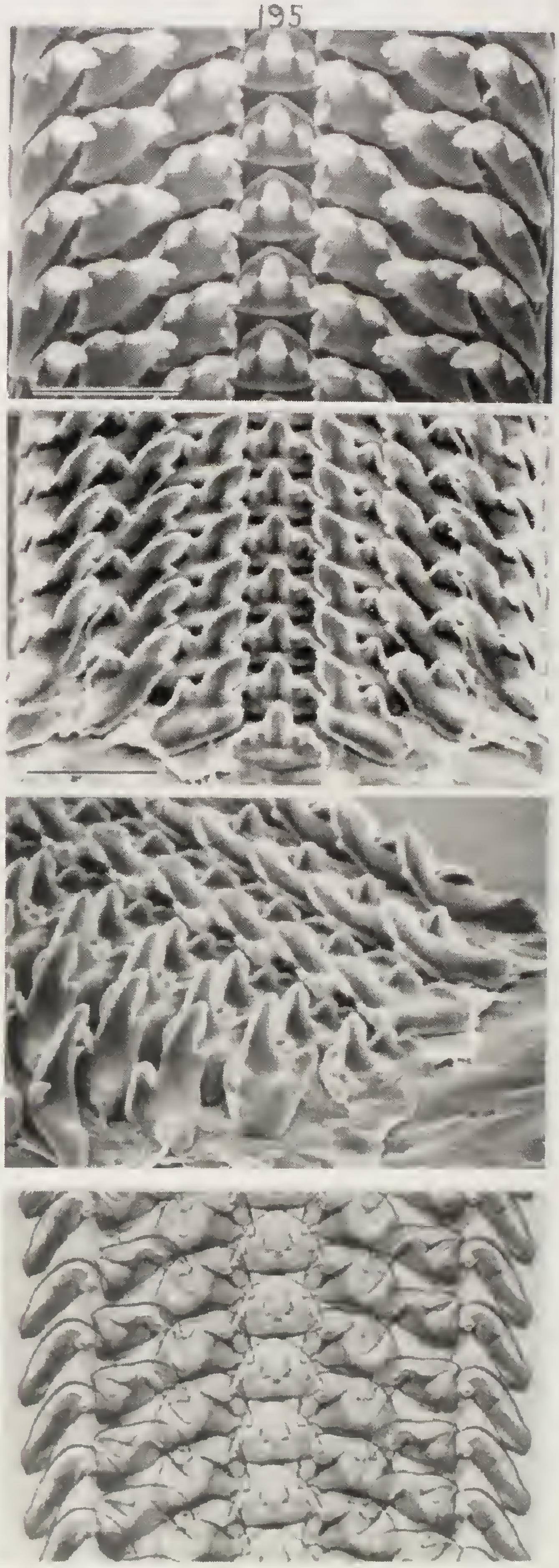

Figure 25. *Lyncina sulcidentata*

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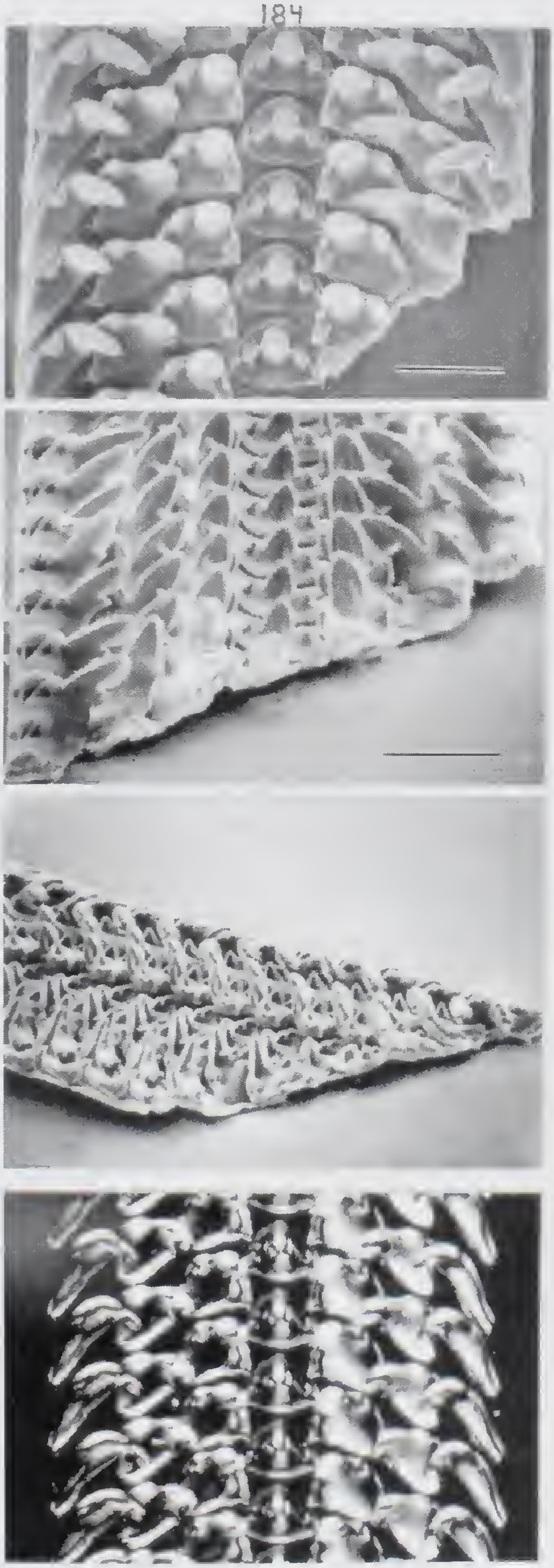

Figure 26. hybrid *schilderorum/sulcidentata*

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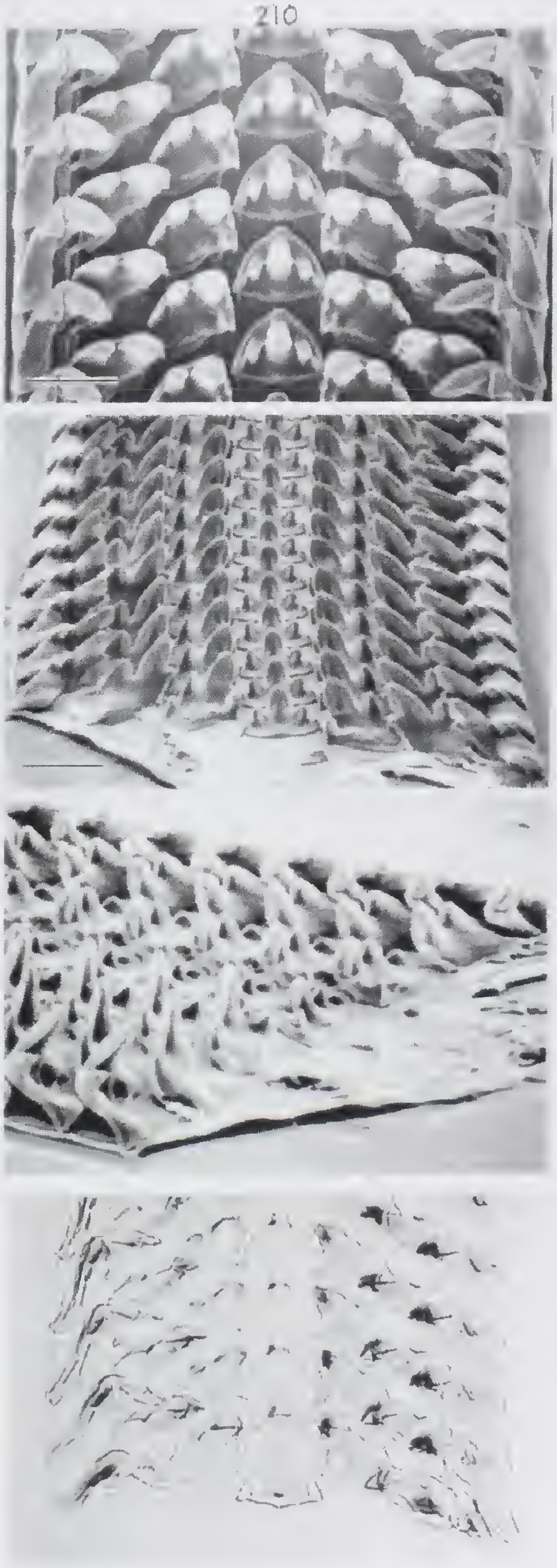

Figure 27. *Lyncina ventriculus*

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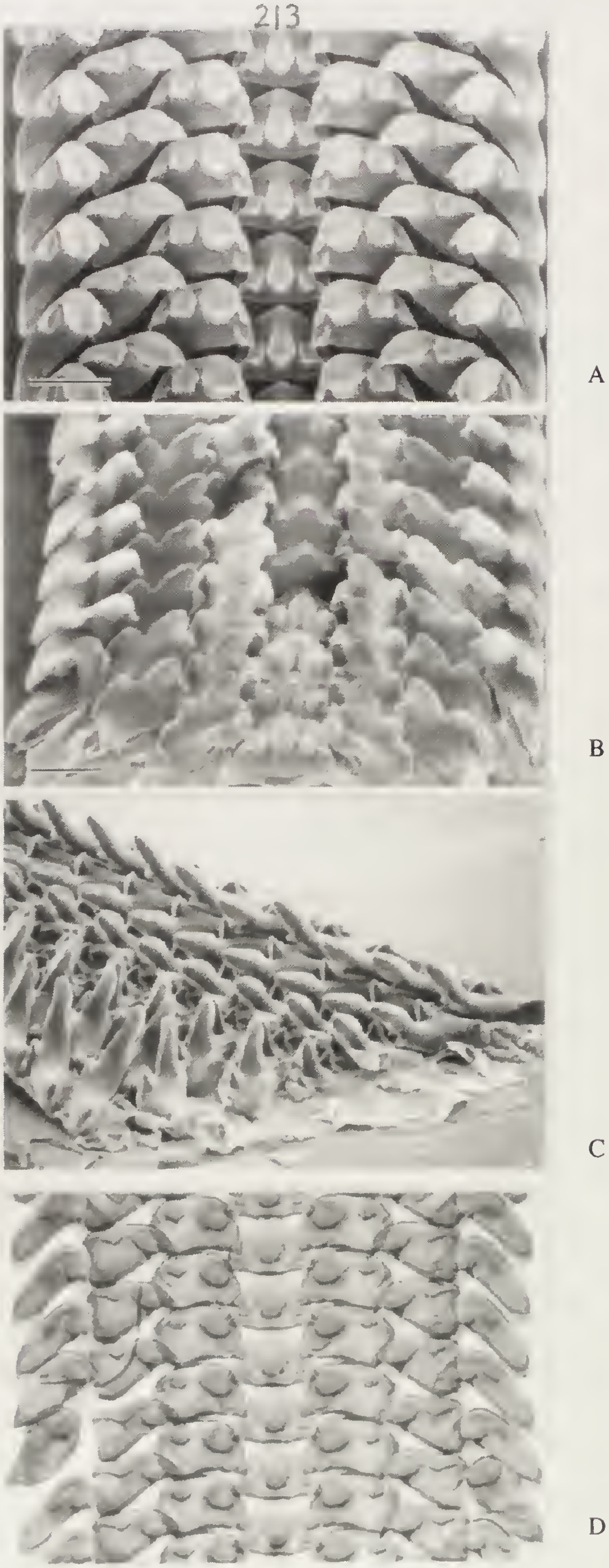
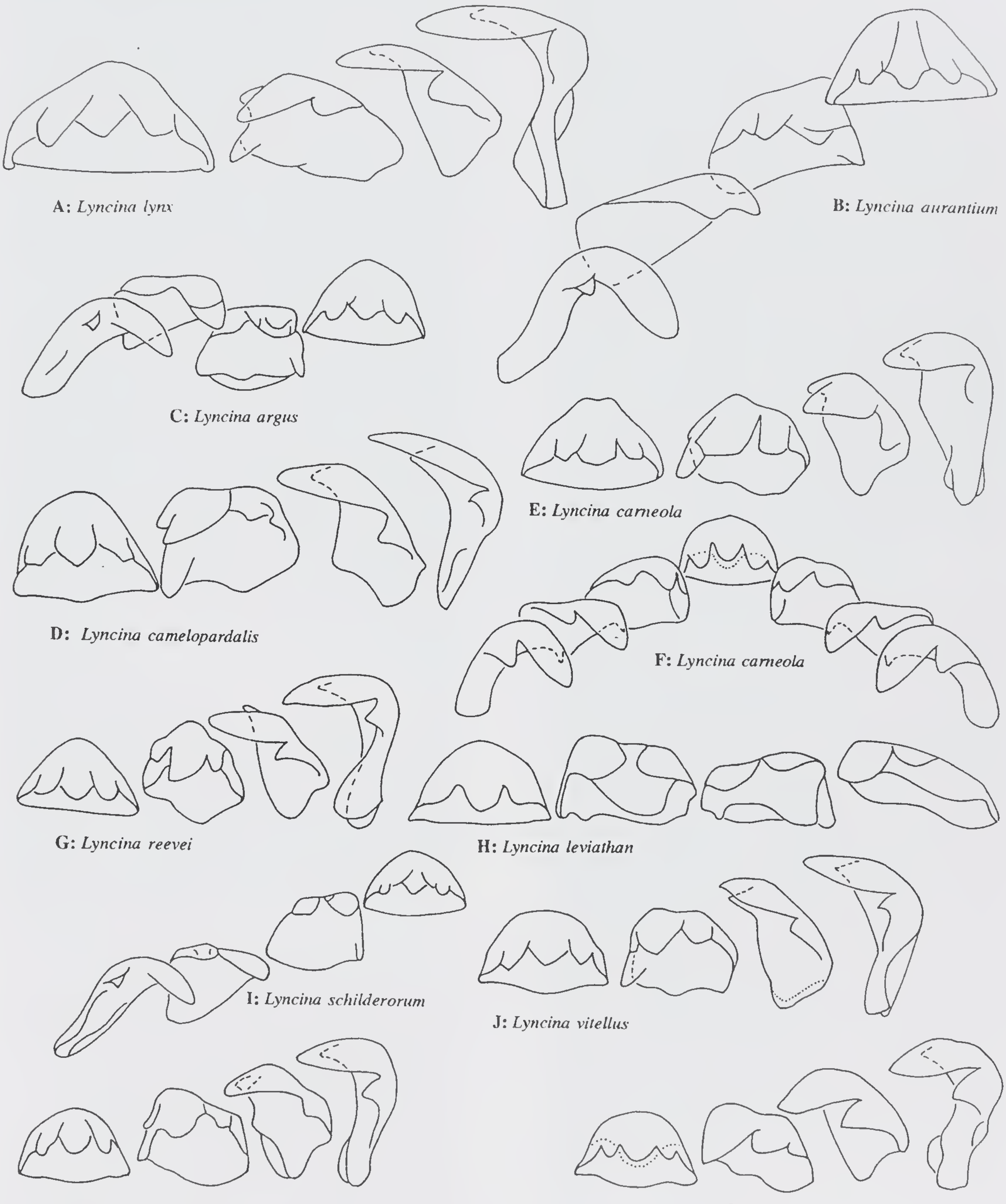


Figure 28. *Lyncina vitellus*



A: *Lyncina lynx*

B: *Lyncina aurantium*

C: *Lyncina argus*

D: *Lyncina camelopardalis*

E: *Lyncina carneola*

F: *Lyncina carneola*

G: *Lyncina reevei*

H: *Lyncina leviathan*

I: *Lyncina schilderorum*

J: *Lyncina vitellus*

K: *Lyncina sulcidentata*

L: *Lyncina ventriculus*

Figure 29. Lynx pattern drawings

The Erosa Pattern (Figures 4, 6, 7E, 10, 30-62).
Model species: *Erosaria erosa* (Linnaeus, 1758).

Species: *Erosaria albuginosa* (Gray, 1825); *E. boivinii* (Kiener, 1843); *E. cernica* (Sowerby, 1870); *E. citrina* (Gray, 1825); *E. eburnea* (Barnes, 1824); *E. englerti* (Summers & Burgess, 1965); *E. erosa* (Linnaeus, 1758); *E. gangranosa* (Dillwyn, 1817); *E. guttata* (Gmelin, 1791); *E. helvola* (Linnaeus, 1758); *E. kingae* (Rehder & Wilson, 1975); *E. labrolineata* (Gaskoin, 1849); *E. lamarckii* (Gray, 1825); *E. marginalis* (Dillwyn, 1827); *E. miliaris* (Gmelin, 1791); *E. nebrites* (Melvill, 1888); *E. ocellata* (Linnaeus, 1758); *E. poraria* (Linnaeus, 1758); *E. spurca* (Linnaeus, 1758); *E. turdus* (Lamarck, 1810); *E. (Paulonaria) beckii* (Gaskoin, 1836); *E. (P.) dillwyni* (Schilder, 1922); *E. (P.) macandrewi* (Sowerby, 1870); *E. (P.) thomasi* (Crosse, 1865); *E. (Ravitrona) caputdraconis* (Melvill, 1888); *E. (R.) caputserpentis* (Linnaeus, 1758); *Monetaria moneta* (Linnaeus, 1758); *M. (Ornamentaria) annulus* (Linnaeus, 1758); *M. (O.) obvelata* (Lamarck, 1810); *Naria irrorata* (Gray, 1828); *Pustularia (Ipsa) childreni* (Gray, 1825).

The defining characters in this pattern are the relatively small, crowded teeth, with the laterals and marginals overlapping each other and the central tooth. In sixty percent of the specimens, the central tooth is in the 100 to 150 micron range (mean dimensions 122x102 microns; n=42) and is nearly as wide as it is long (mean length/width ratio 1.1; n=42). The central is tricuspid with the lateral cusps indented. The anterior edge is straight or barely curved. A pair of ridges, visible with SEM, extends from mid-shaft to base, terminating in a shelf where the base meets the radular membrane. A dark staining internal bract visible with OM is present near the base of the shaft, and a transparent subtending bract on the base is also visible with OM. There are no basal denticles, but the corners of the base may be drawn out. The lateral teeth are slightly larger than the central. Two prominent basal denticles, one facing the central tooth, the other the marginal teeth, are present. The marginals, the inner wider than the outer, are bladelike in profile, each with a single, strongly projecting basal denticle.

Central tooth dimensions of 42 specimens of *Erosaria:* 50x45 microns in *E. dillwyni* to 240x145 microns in *E. guttata*.
No. of radular rows: 75 to 260 (n=21).
No. radular rows per mm radula: 4.6 to 17.9 (n=44).

The 31 species referred to this pattern are all included in M. Schilder & F. Schilder's (1971) tribe Erosariini, but in three genera, *Erosaria* Troschel, *Naria* Broderip, and *Monetaria* Troschel. Troschel (1863) described a "double contourline" on the basal plate in *Erosaria* and a "single contourline" in *Monetaria*. The difference described appears to have been an artifact in preparation, and we cannot distinguish between the central teeth in *Erosaria* and *Monetaria* in our preparations. Among the species pairs in the tribe are *E. cernica* and *E. thomasi*, *E. erosa* and *E. nebrites*, *E. miliaris* and *E. eburnea*, *E. caputserpentis* and *E. caputdraconis*, and *M. annulus* and *M. obvelata*. The species of *Erosaria* form a cohesive group with branching mantle papillae, the female reproductive system without a bursa copulatrix, and for all those species for which the protoconch is known, a planktonic veliger. Except for *E. albuginosa* of the west coast of Central America and *E. spurca* of the Caribbean, Atlantic, and Mediterranean, the species are typical of the Indo-West Pacific. We see no differences between the radulae of *E. spurca, E. spurca acicularis, E. spurca atlantica, and E. spurca sanctaehelenae*; we display only the radula of a specimen from Ascension Island. Fossils of *Erosaria* are known from the Miocene of Indonesia; fossils of *Monetaria* and *Pustularia childreni* are known from the Miocene of Fiji. Fossils of *Naria* have not been found.

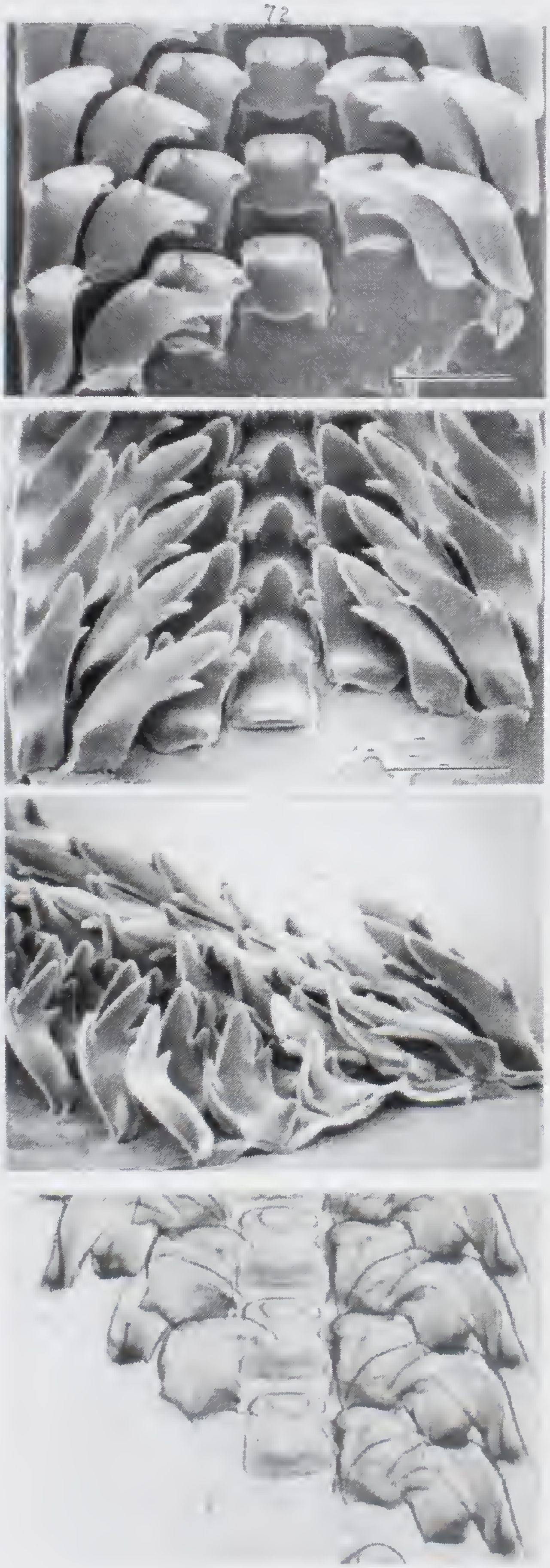


Figure 30. *Erosaria erosa*

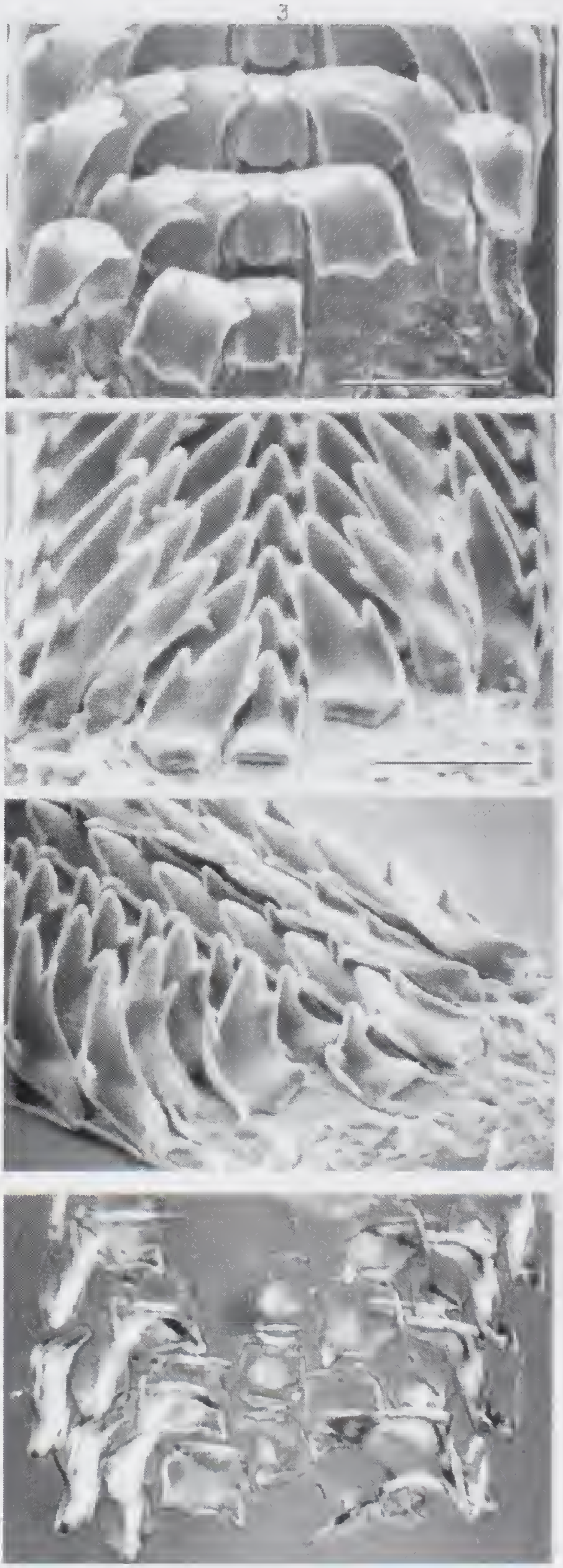


Figure 31. *Erosaria albuginosa*

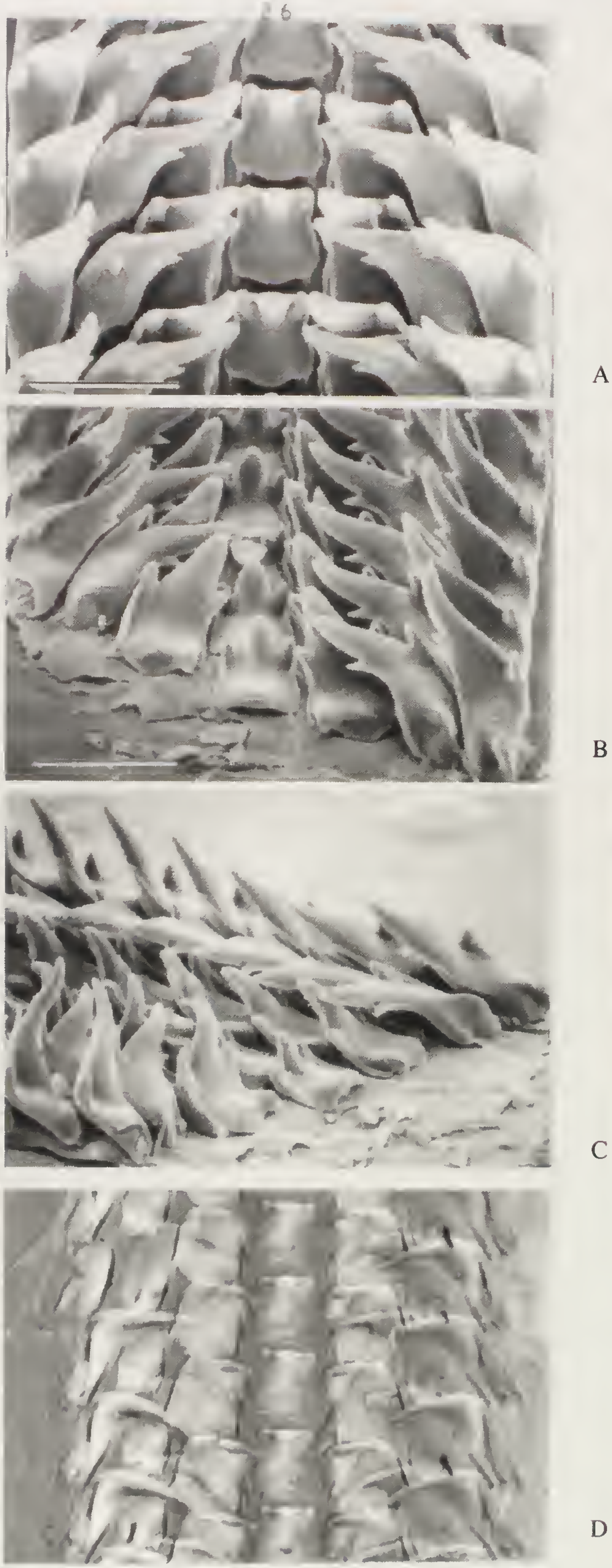


Figure 32. *Erosaria boivinii*

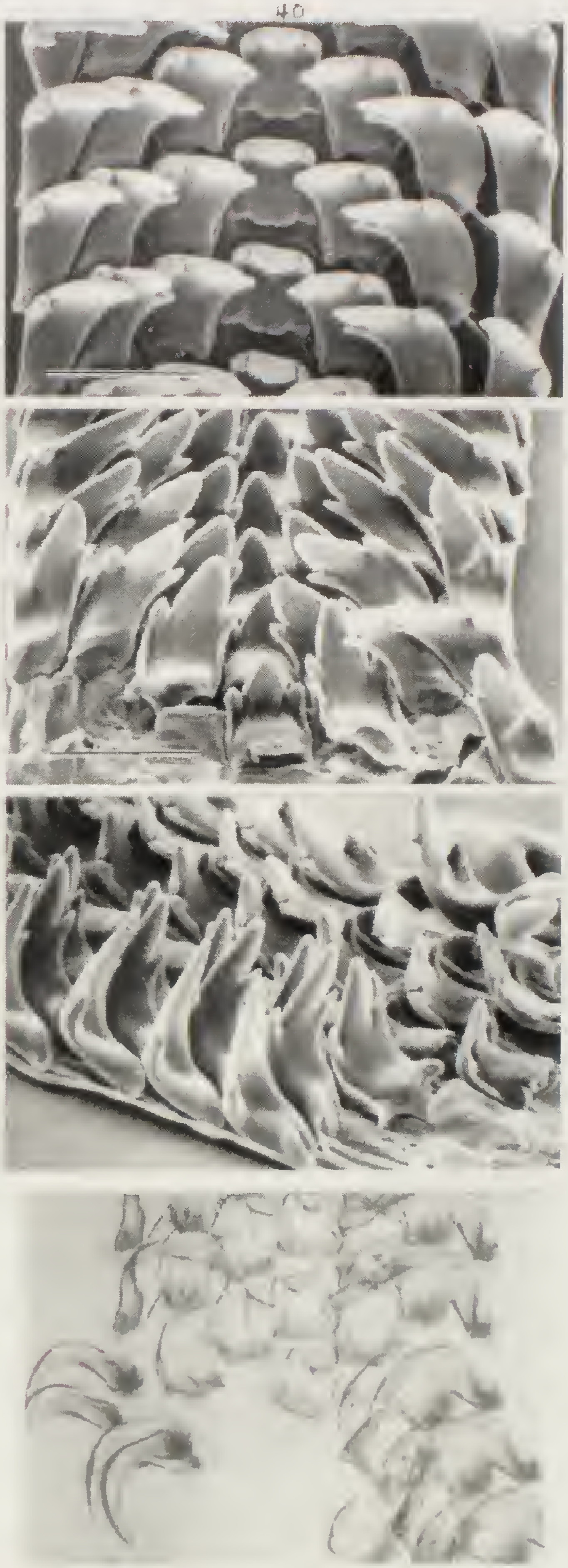


Figure 33. *Erosaria cernica*

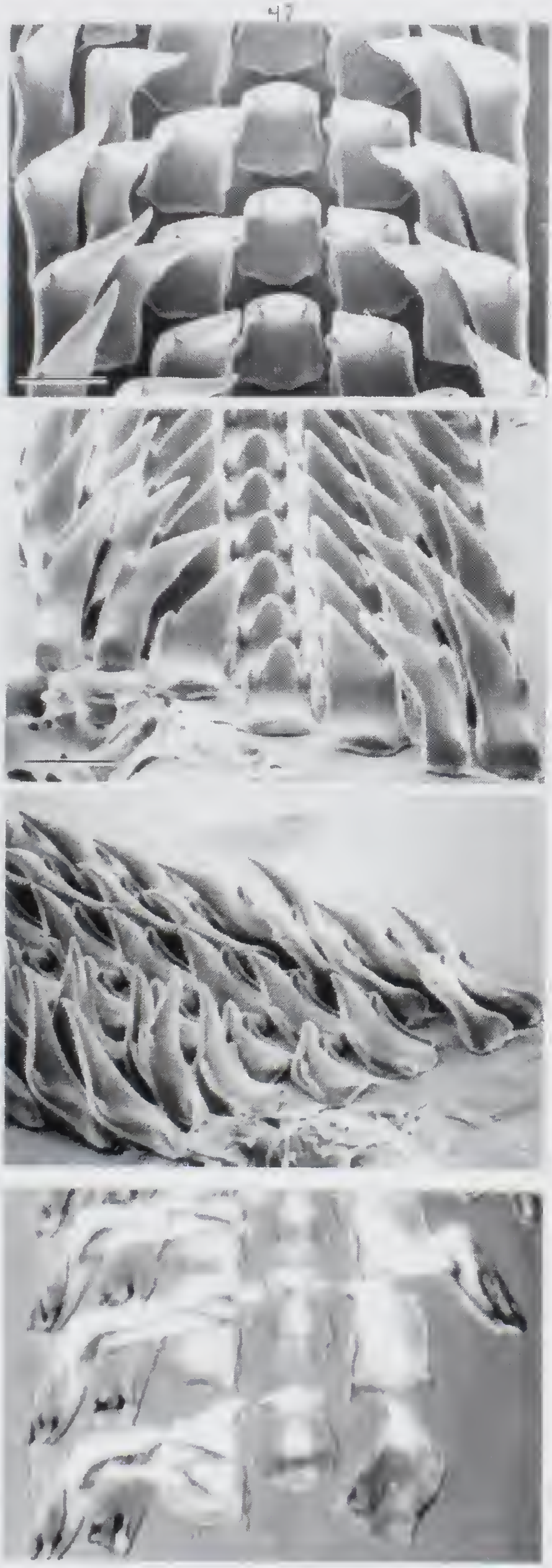


Figure 34. *Erosaria citrina*

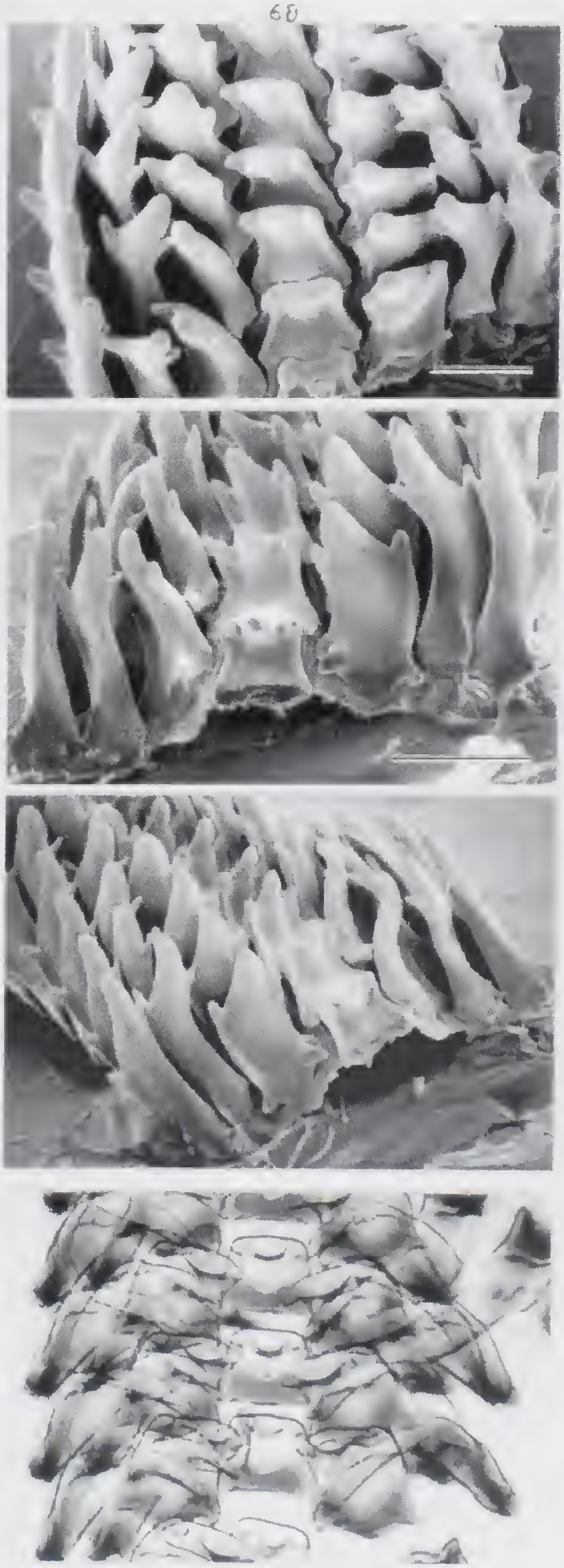


Figure 35. *Erosaria eburnea*

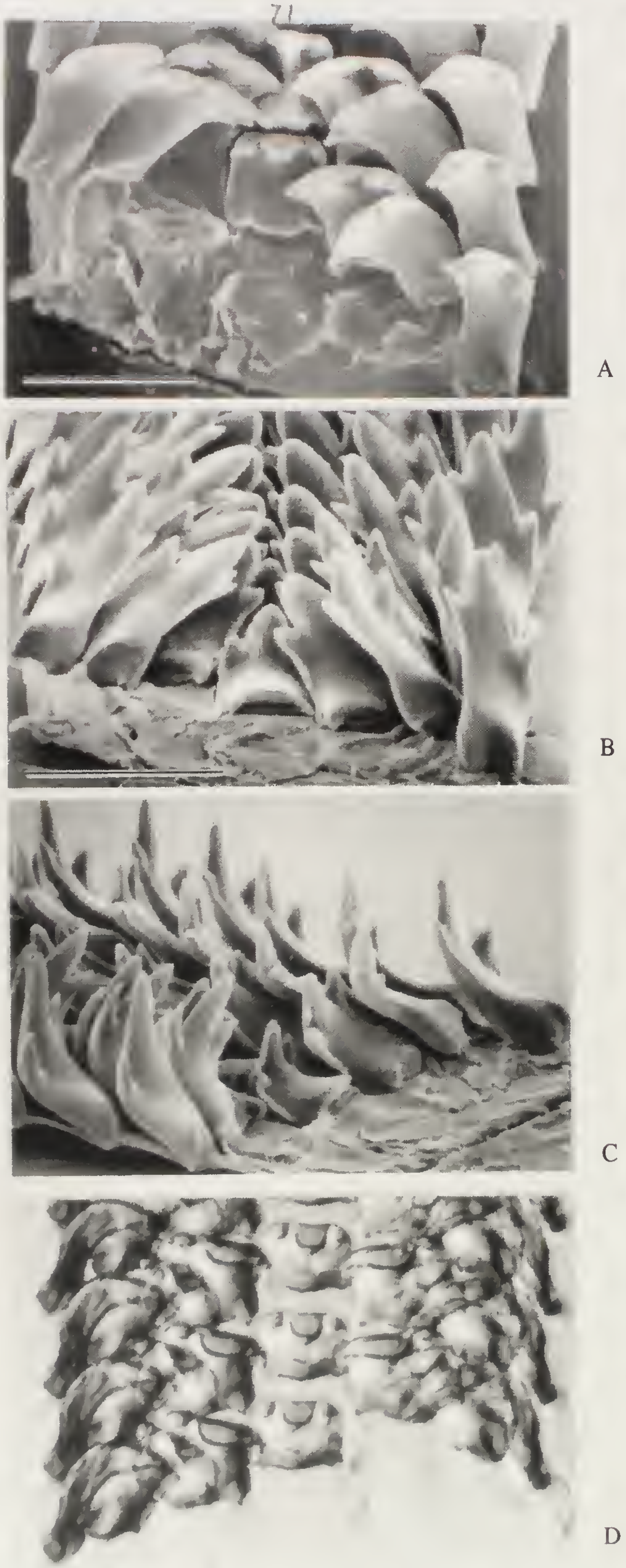


Figure 36. *Erosaria englerti*

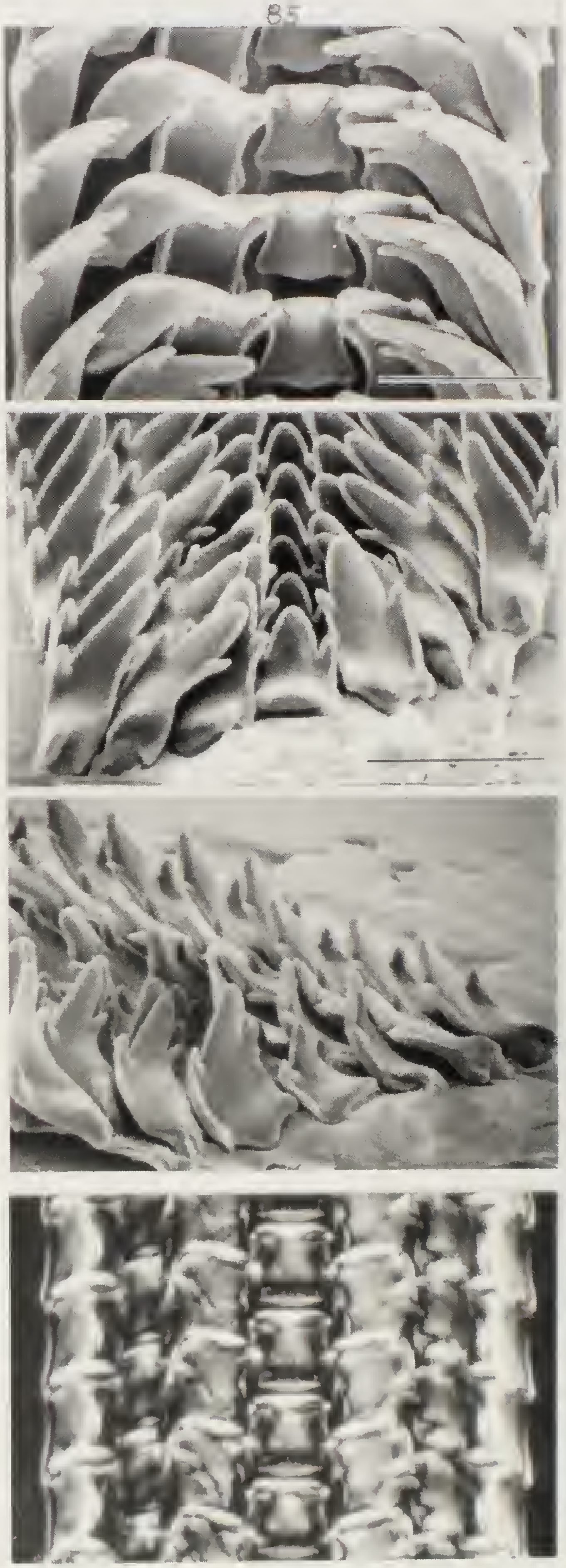


Figure 37. *Erosaria gangranosa*

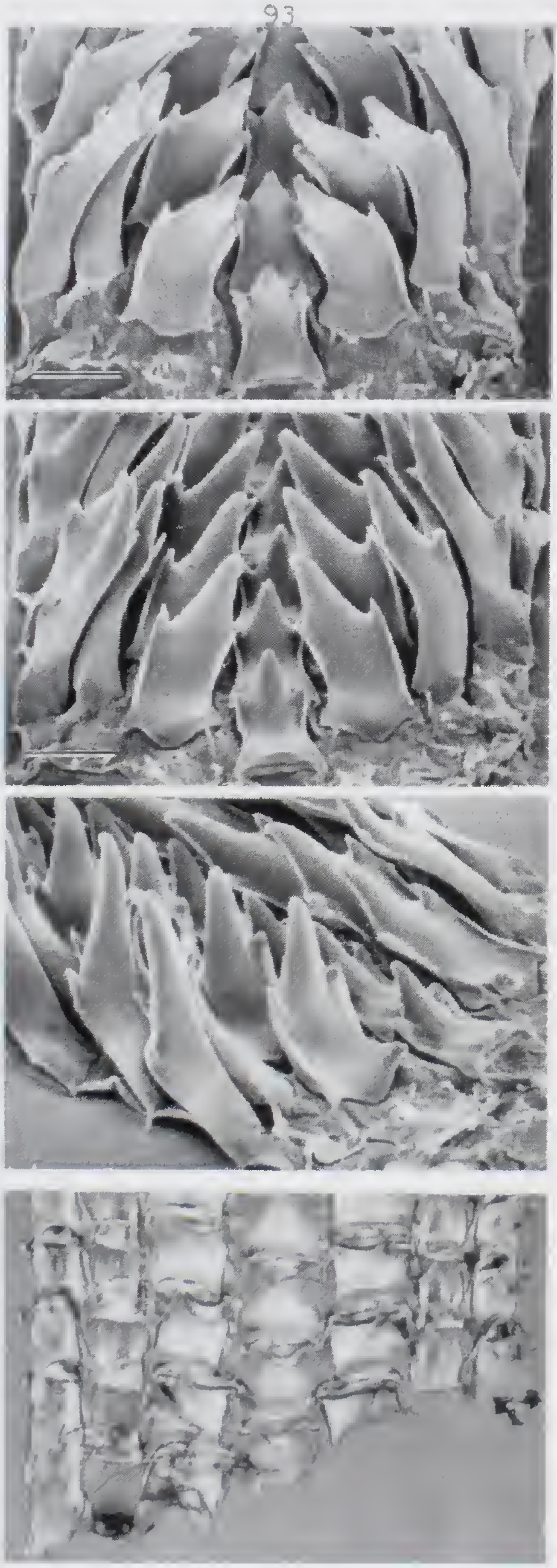


Figure 38. *Erosaria guttata*

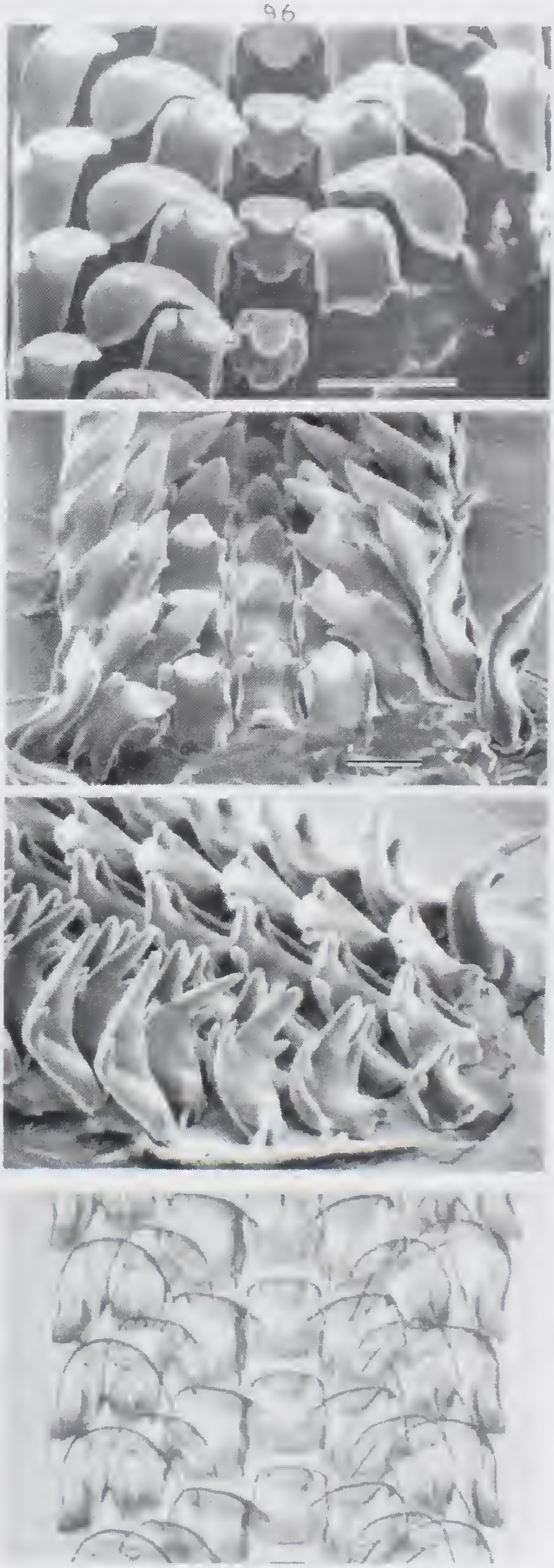


Figure 39. *Erosaria helvola*

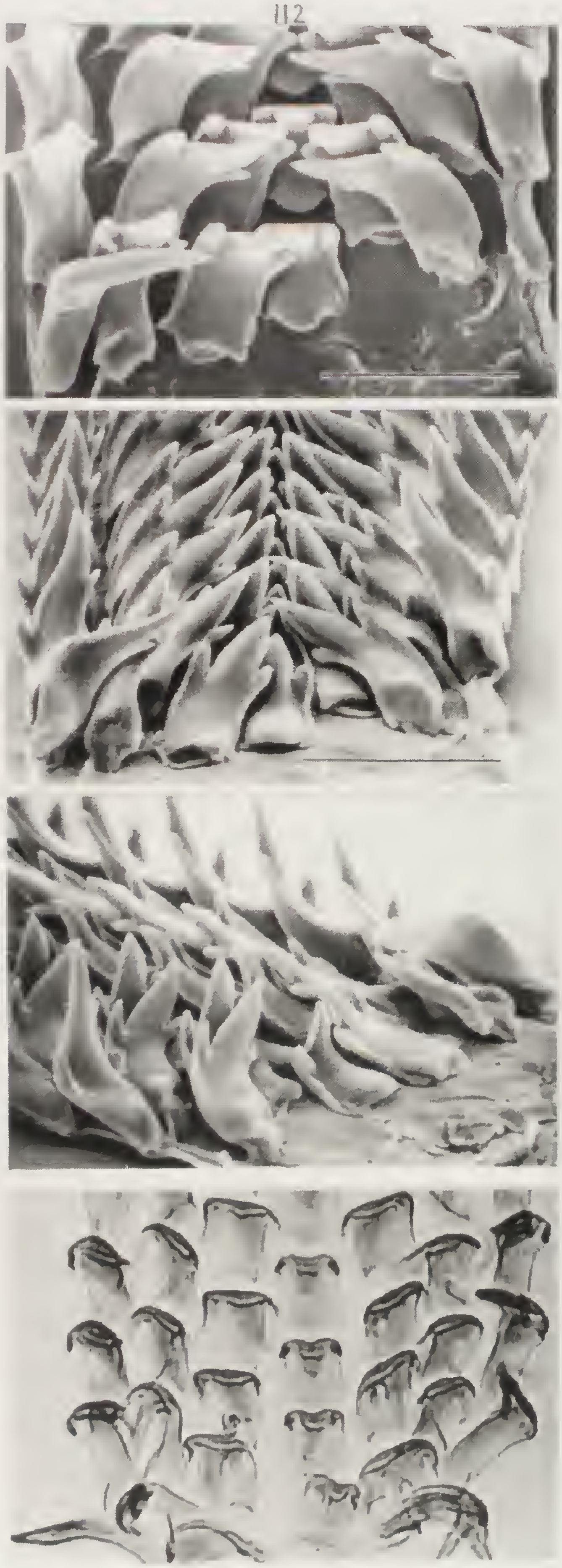


Figure 40. *Erosaria kingae*

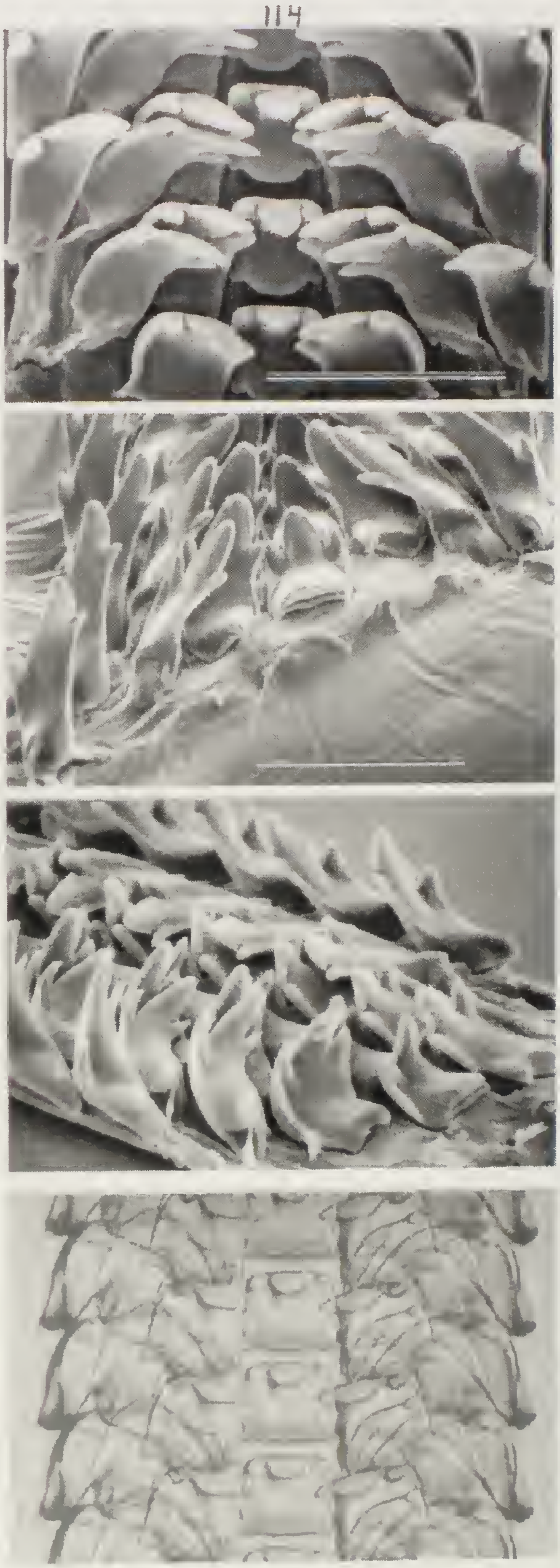


Figure 41. *Erosaria labrolineata*

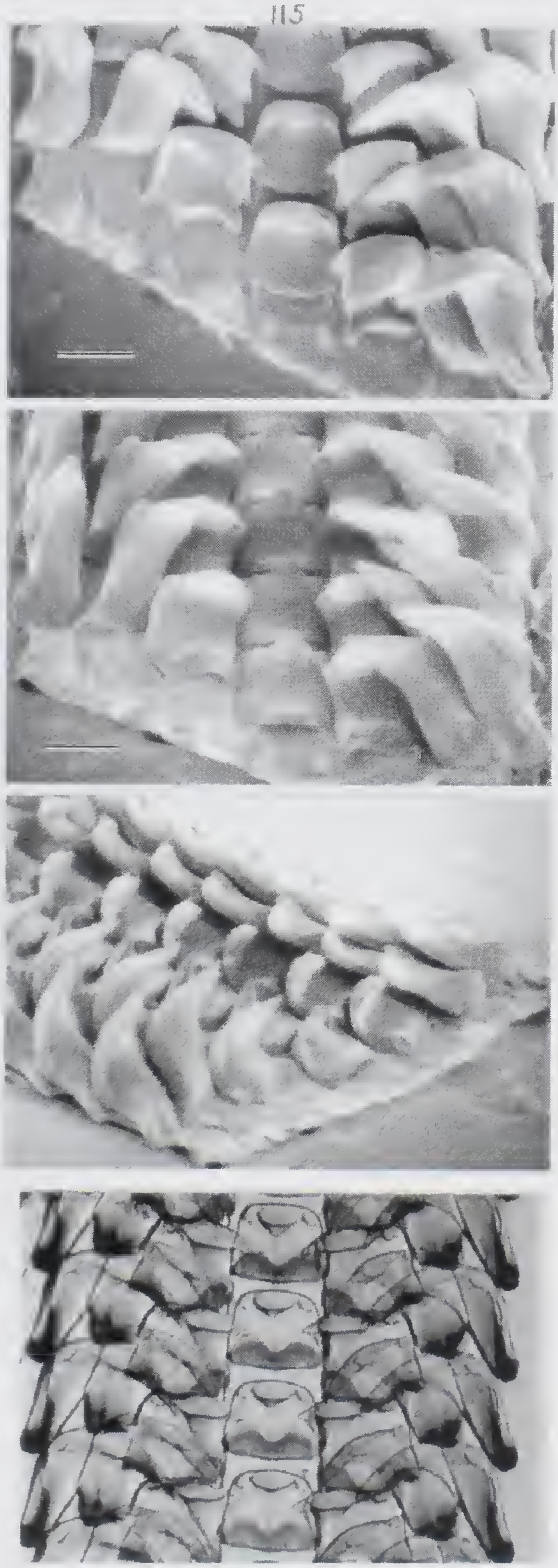


Figure 42. *Erosaria lamarckii*

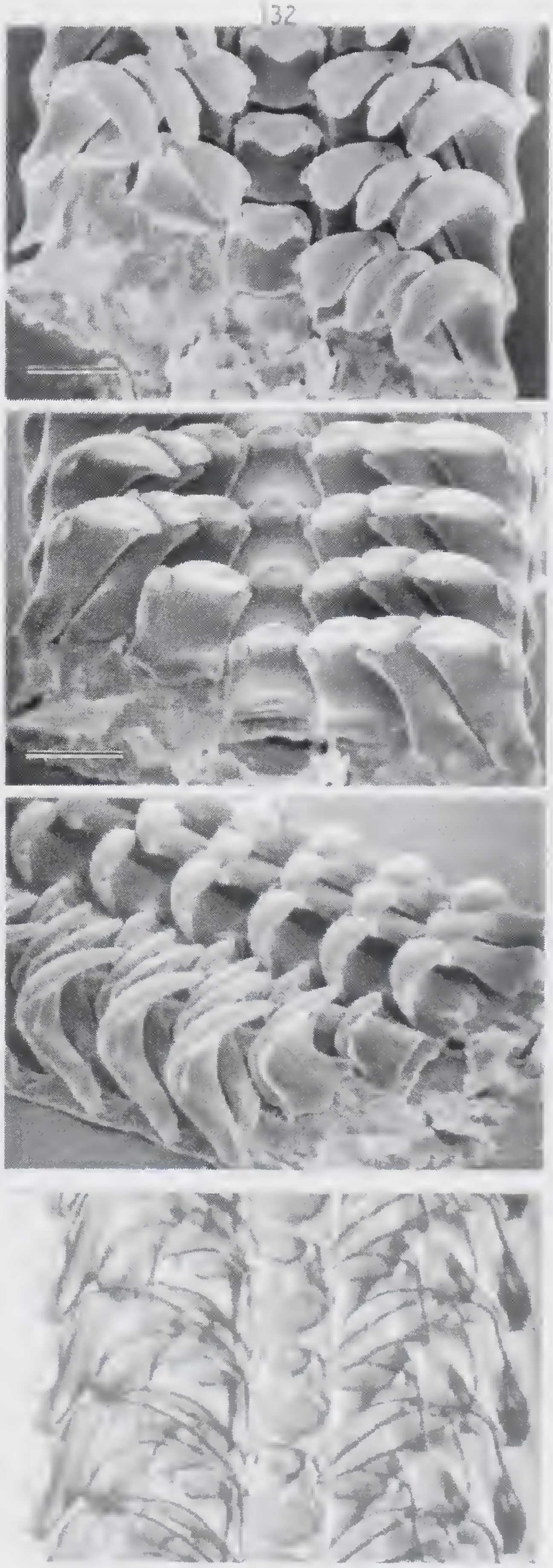


Figure 43. *Erosaria marginalis*

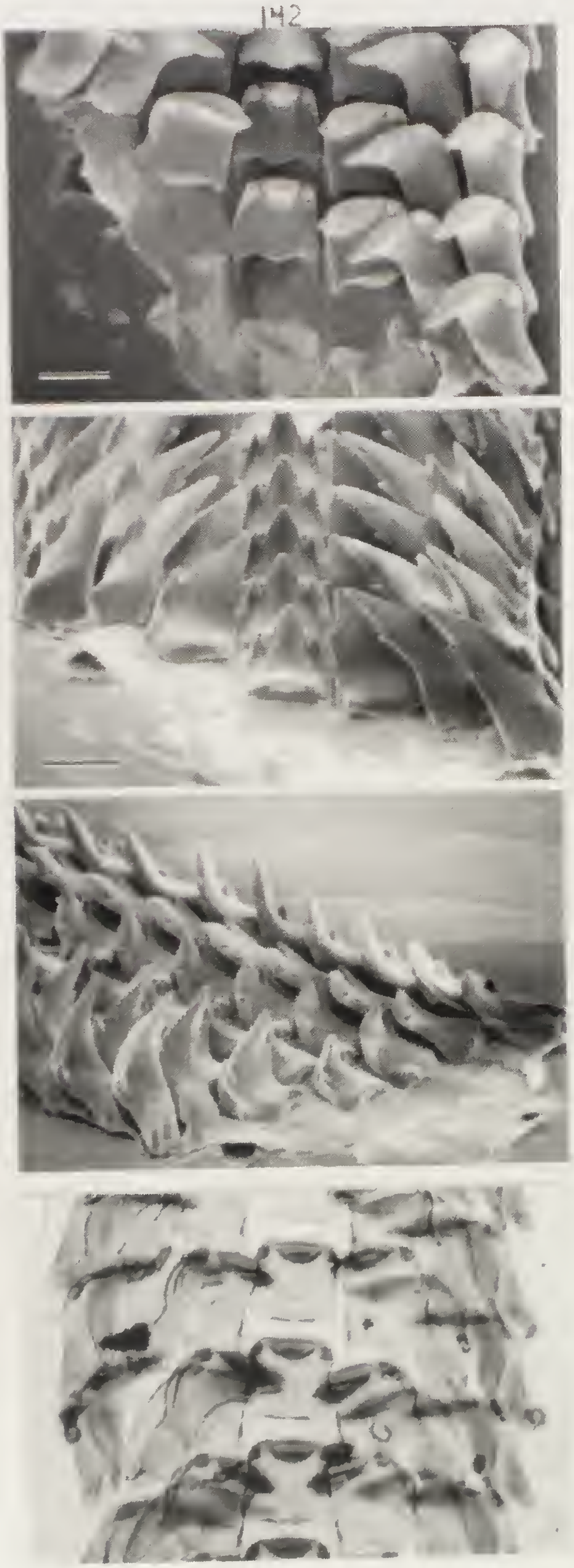


Figure 44. *Erosaria miliaris*

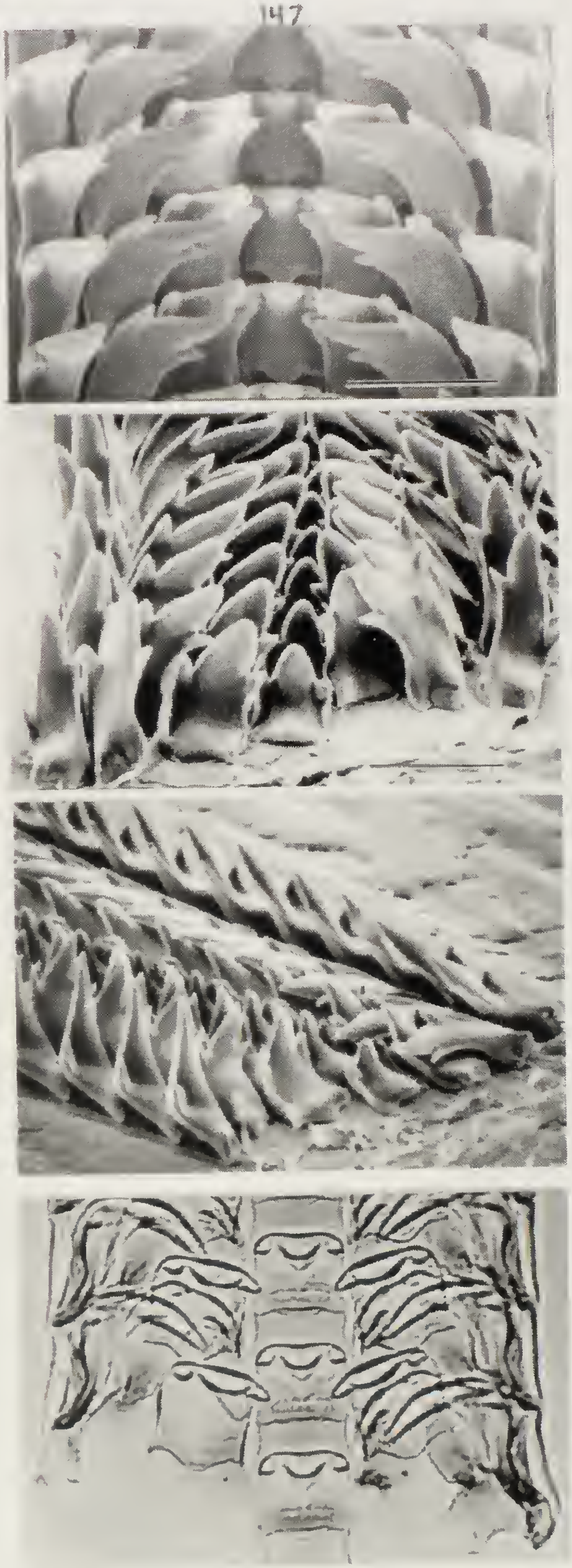


Figure 45. *Erosaria nebrites*

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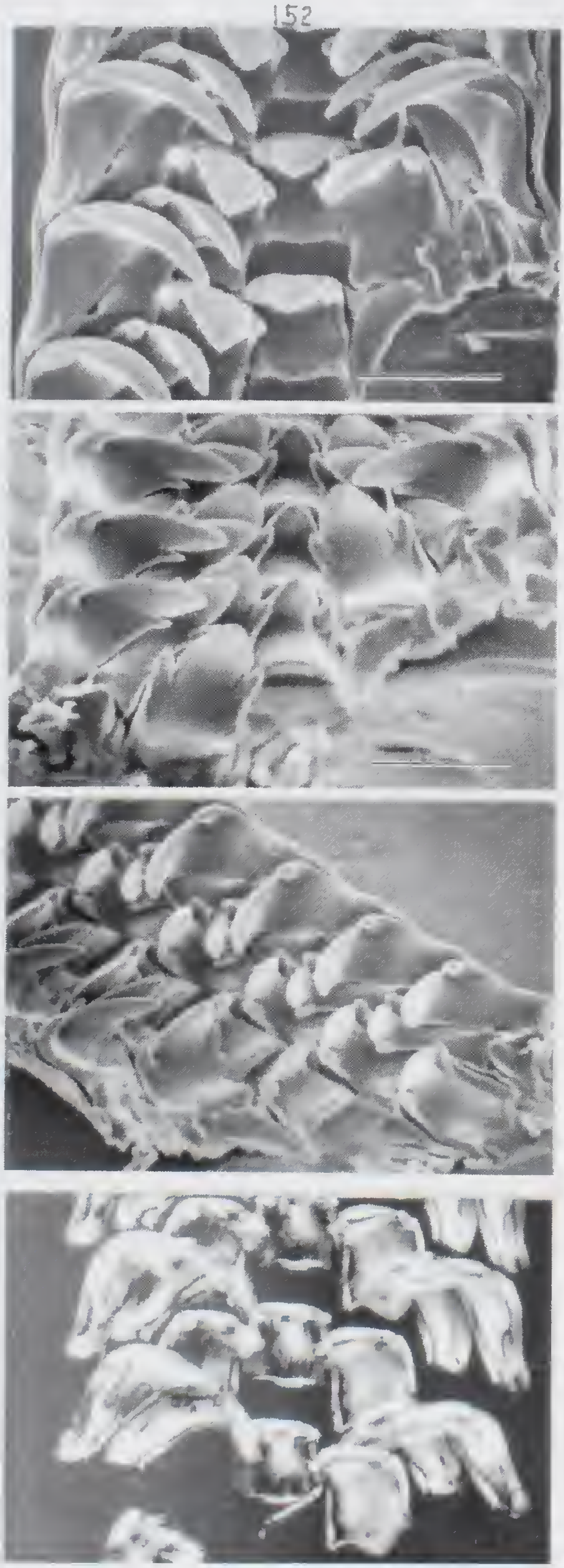

Figure 46. *Erosaria ocellata*

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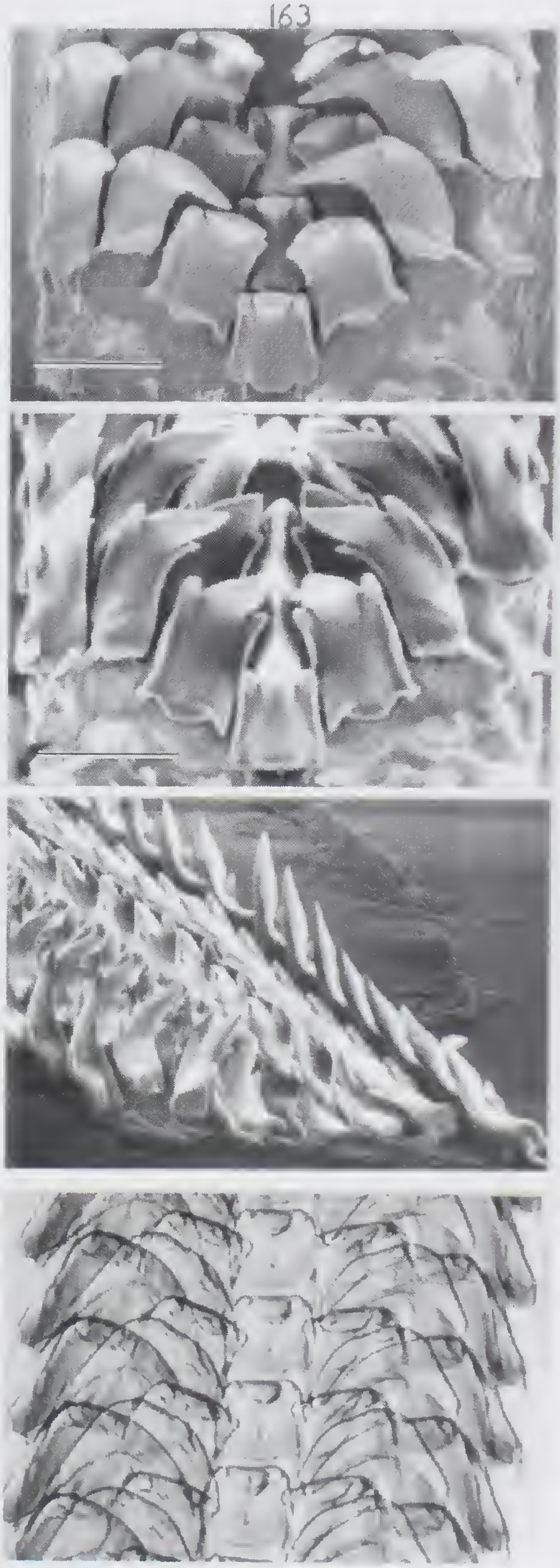


Figure 47. *Erosaria poraria*

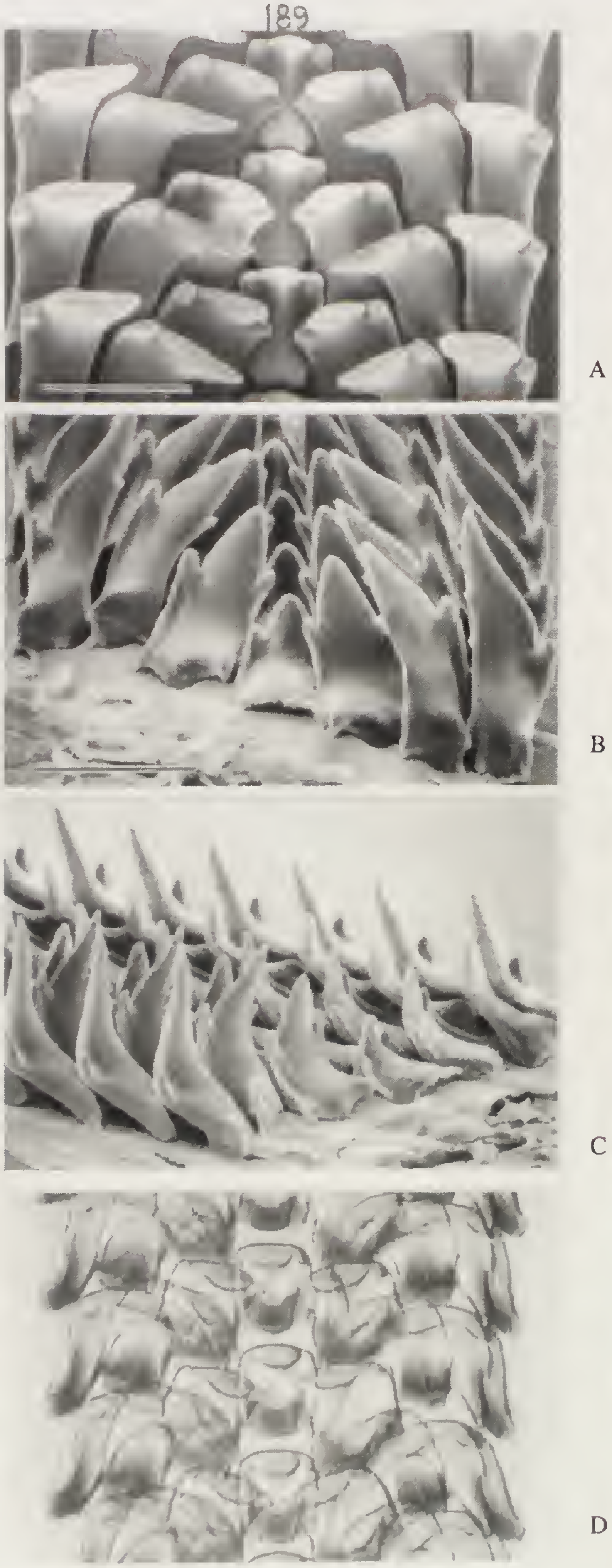


Figure 48. *Erosaria spurca*

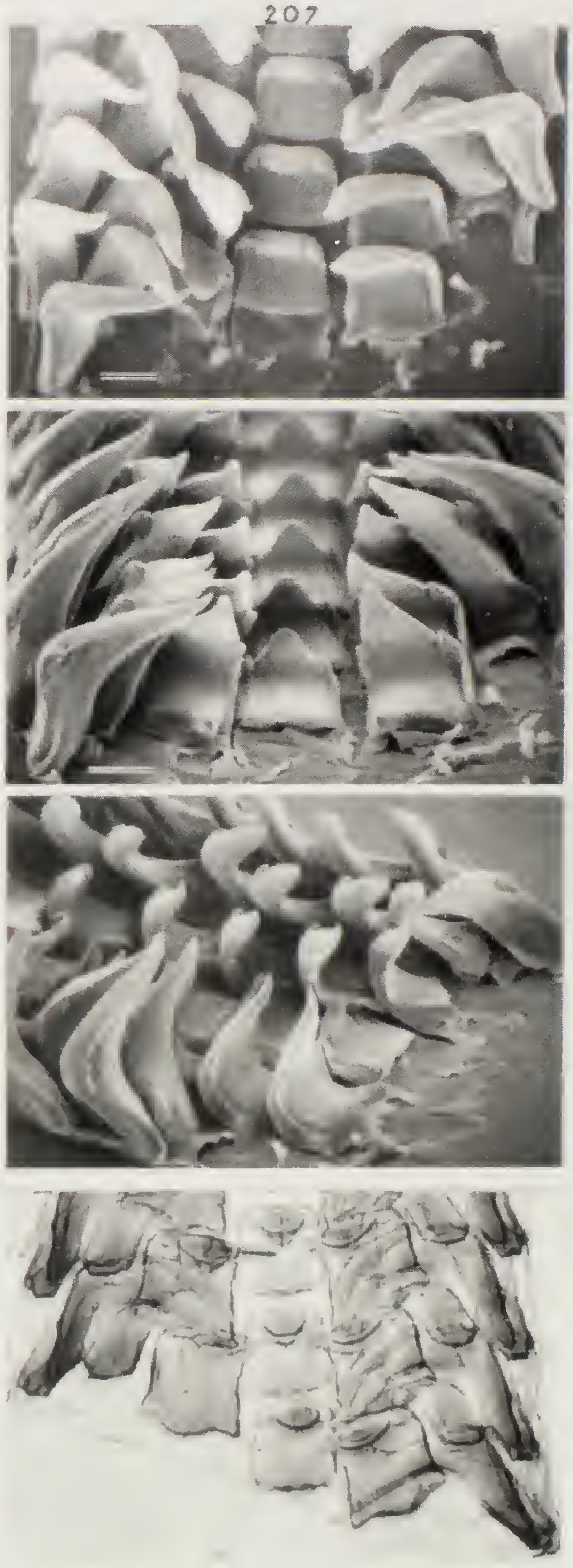


Figure 49. *Erosaria turdus*

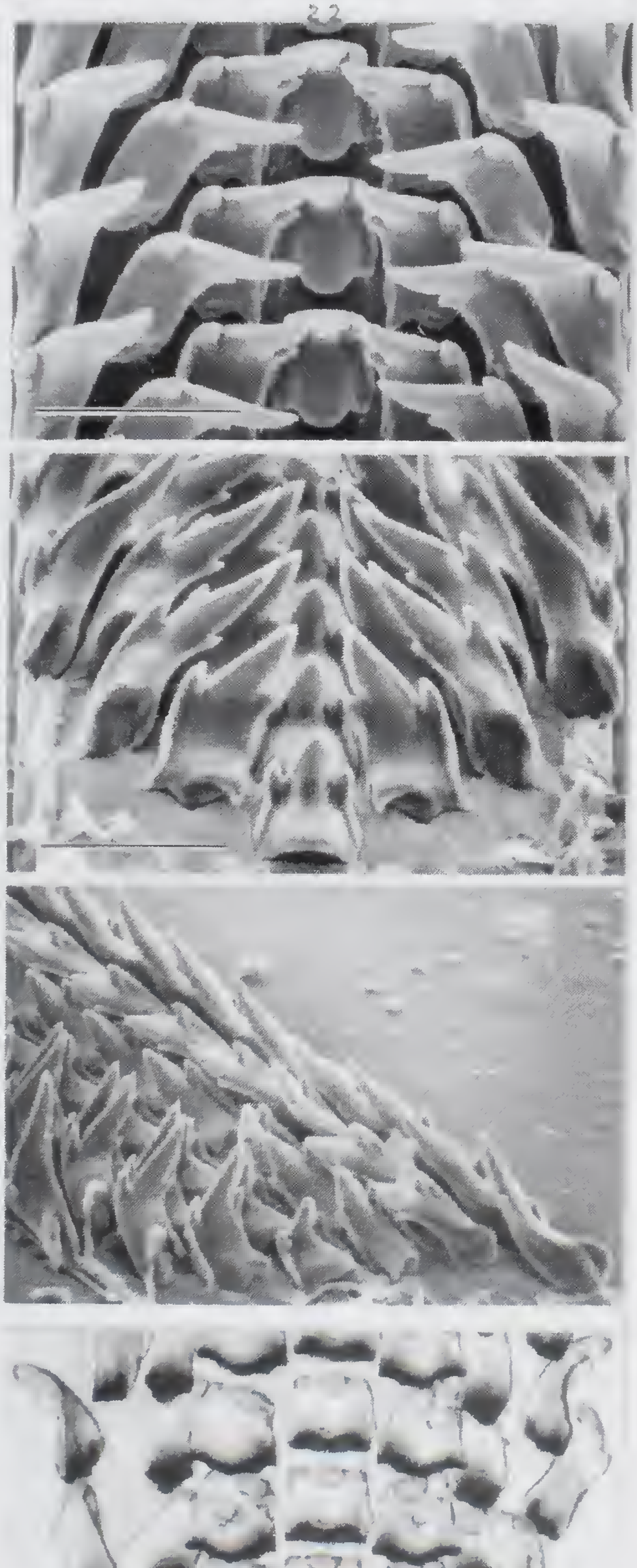


Figure 50. *Erosaria beckii*

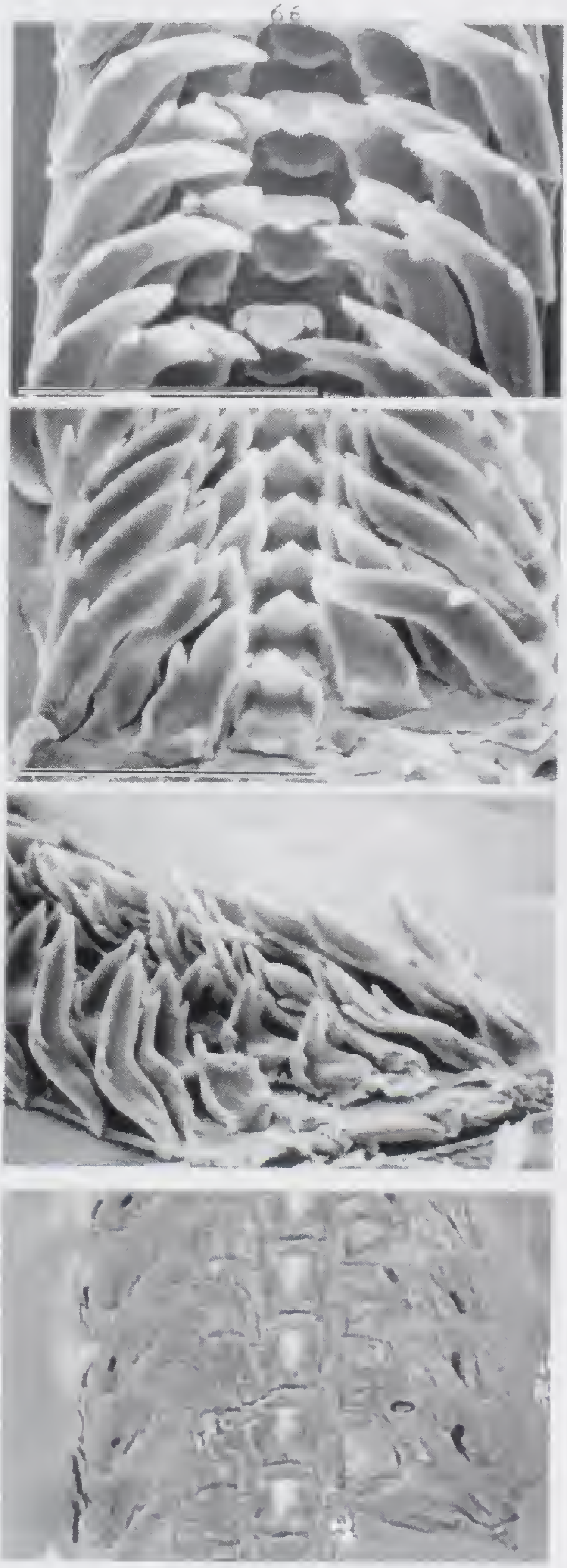


Figure 51. *Erosaria dillwyni*

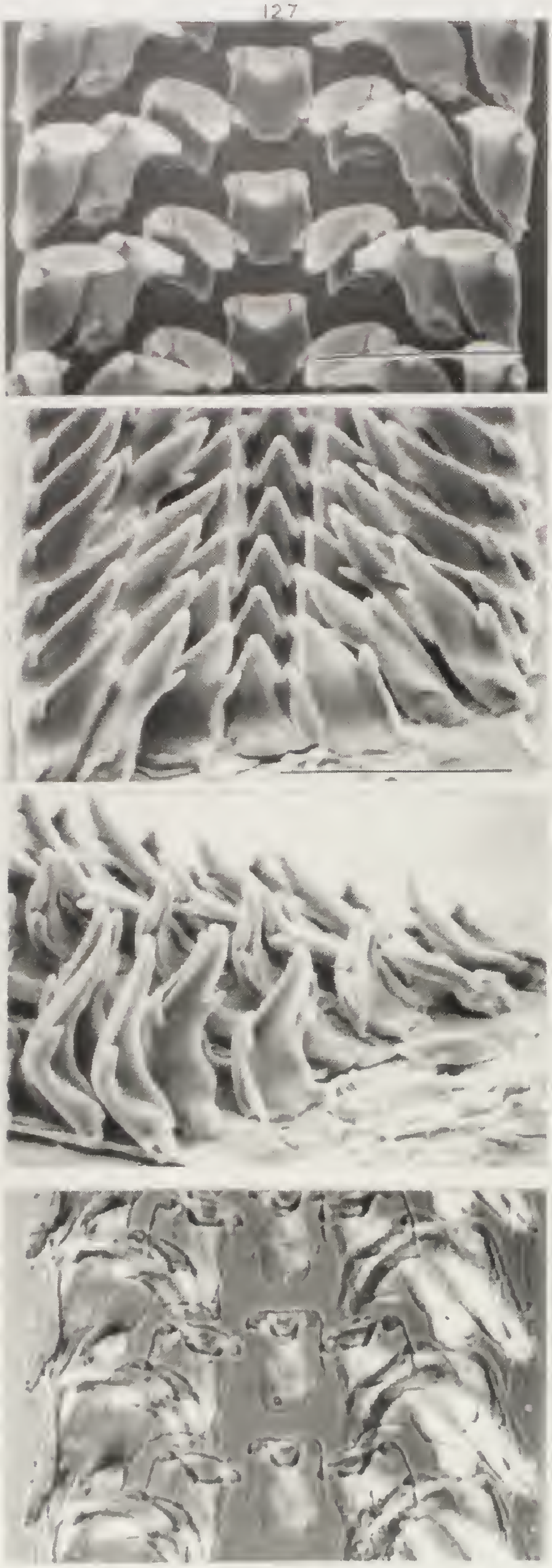


Figure 52. *Erosaria macandrewi*

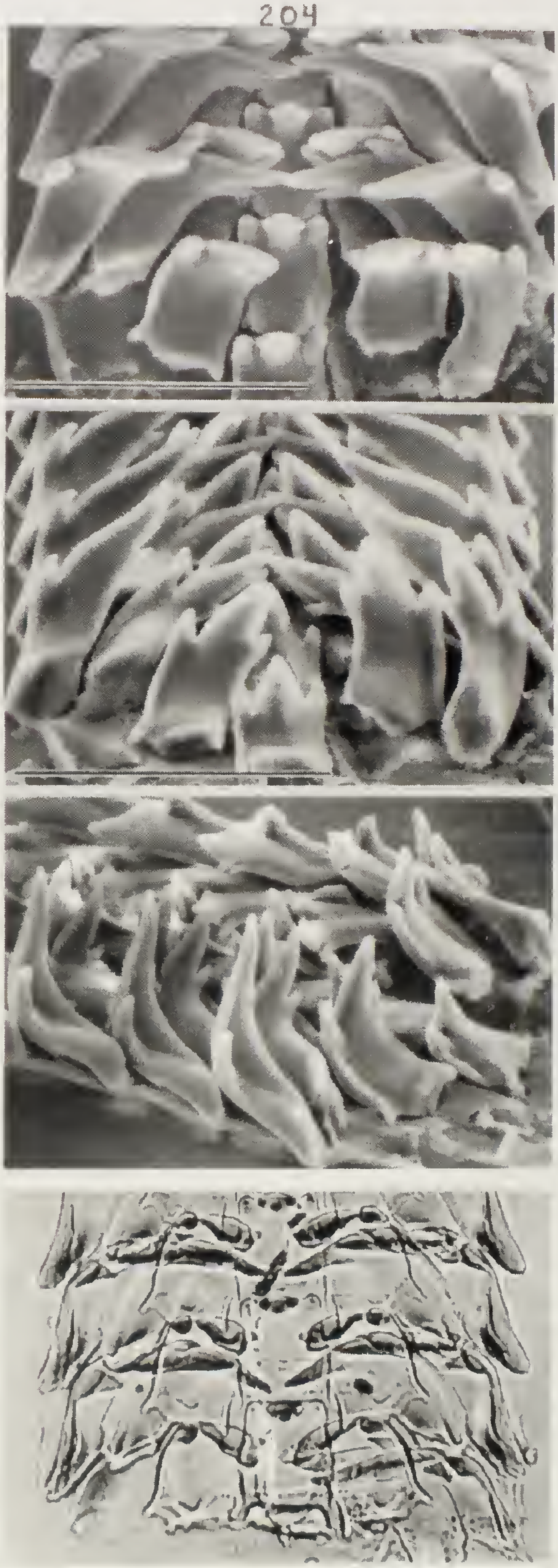


Figure 53. *Erosaria thomasi*

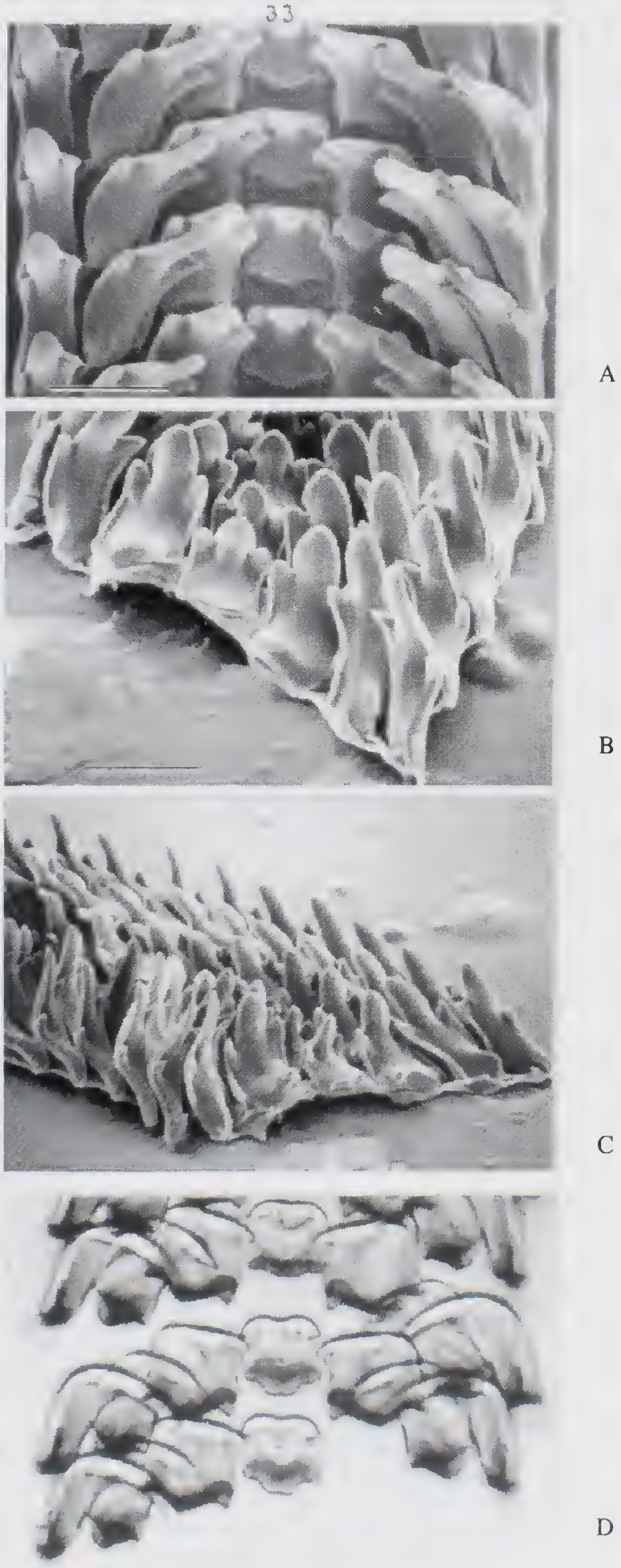


Figure 54. *Erosaria caputdraconis*

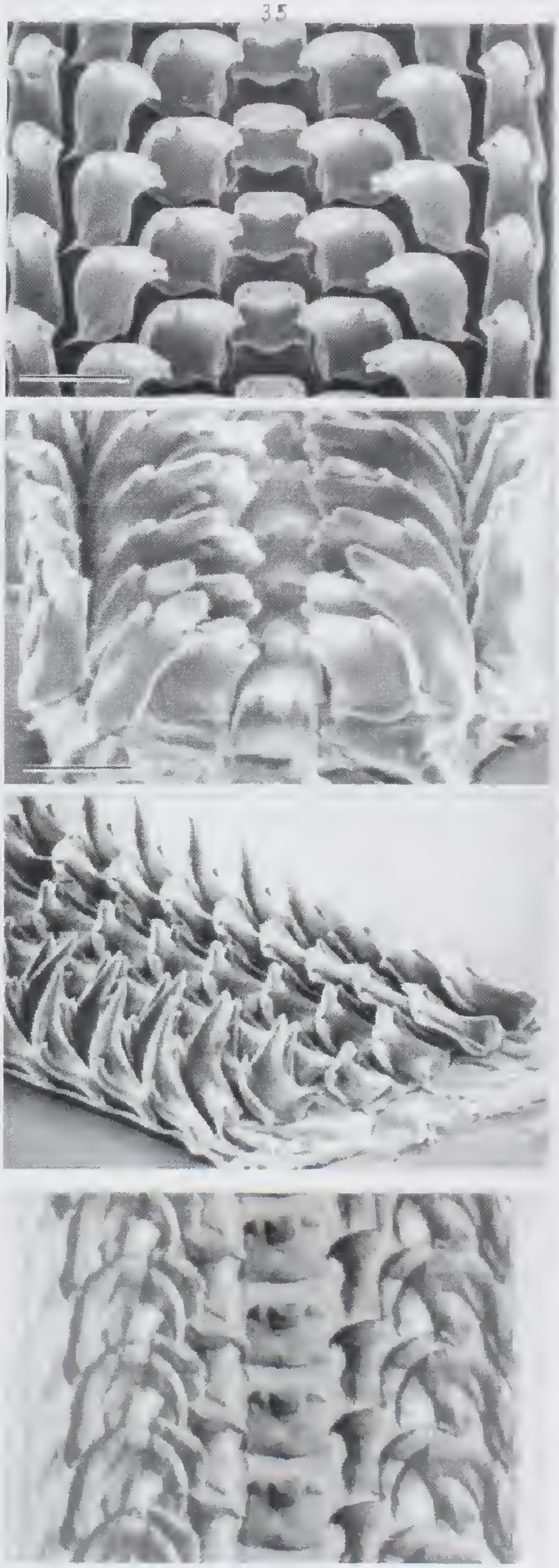


Figure 55. *Erosaria caputserpentis*

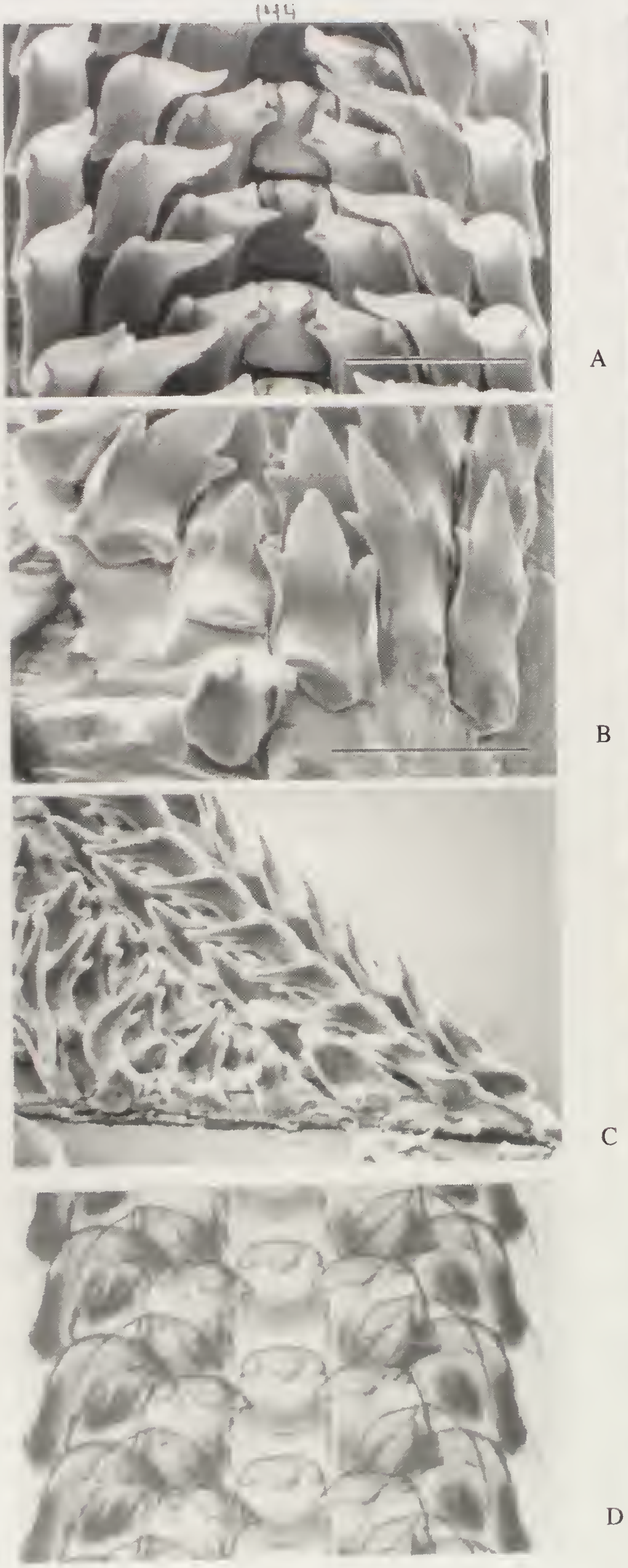


Figure 56. *Monetaria moneta*

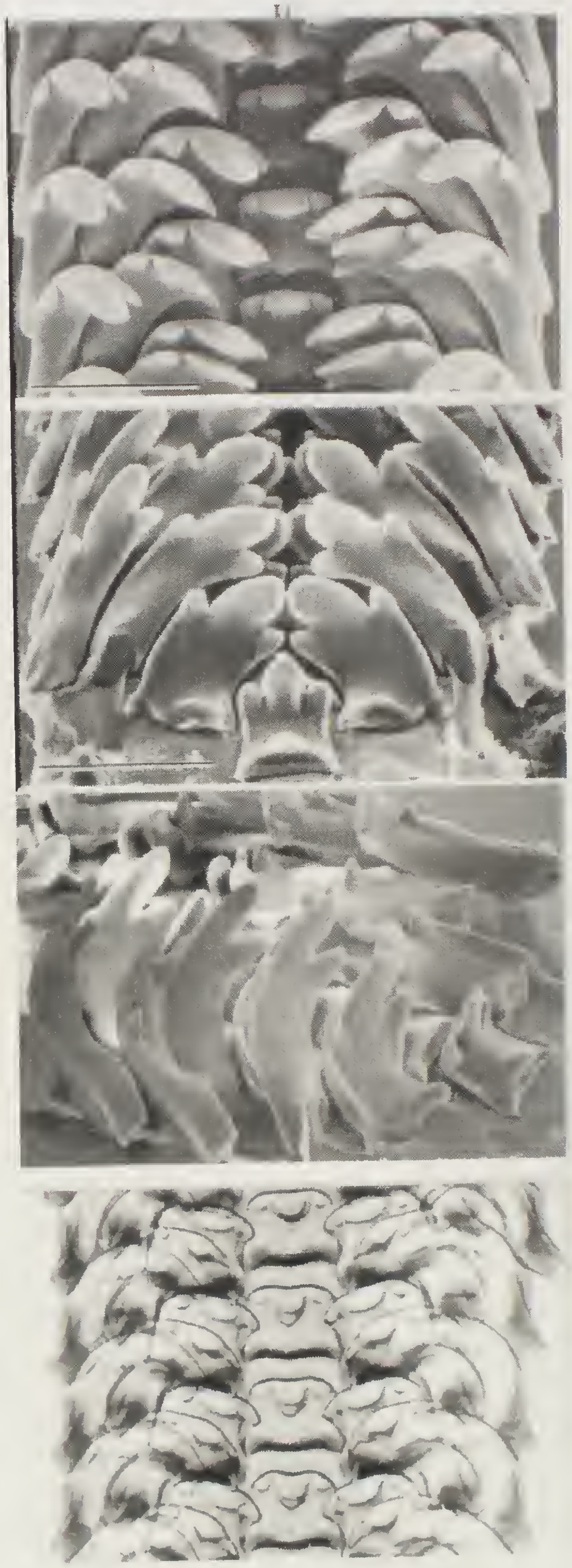


Figure 57. *Monetaria annulus*

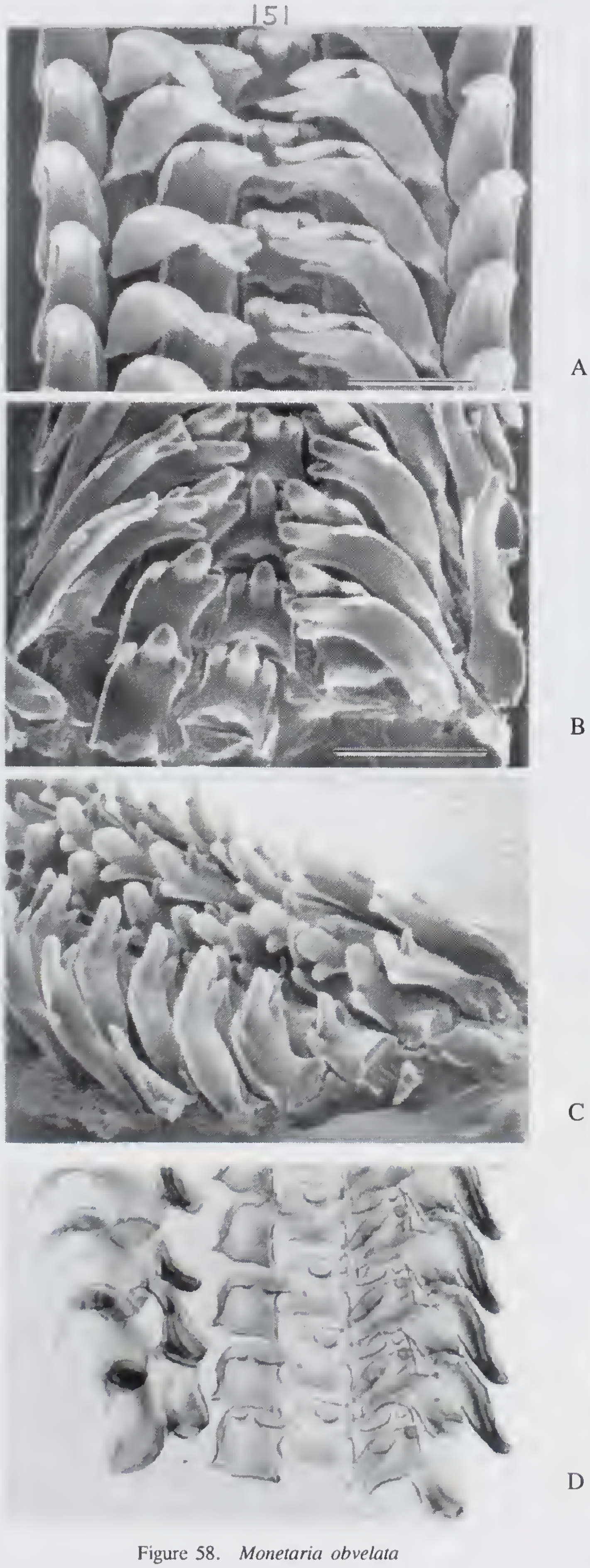


Figure 58. *Monetaria obvelata*

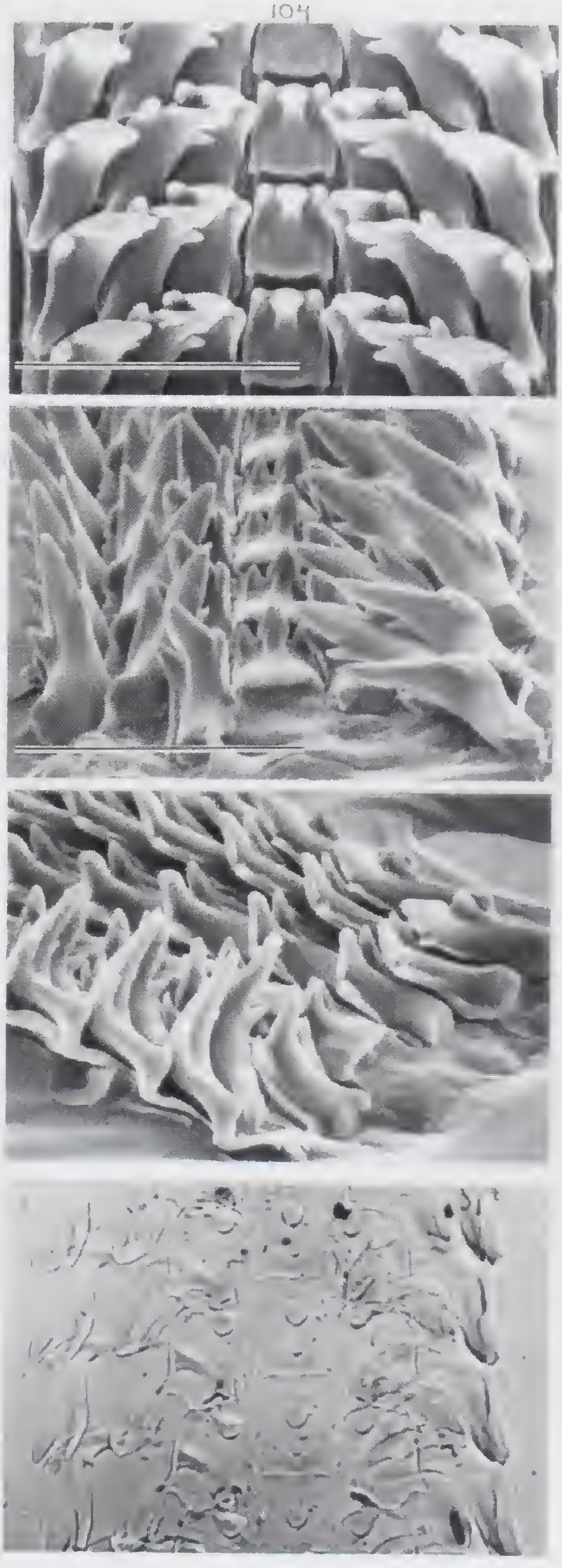


Figure 59. *Naria irrorata*

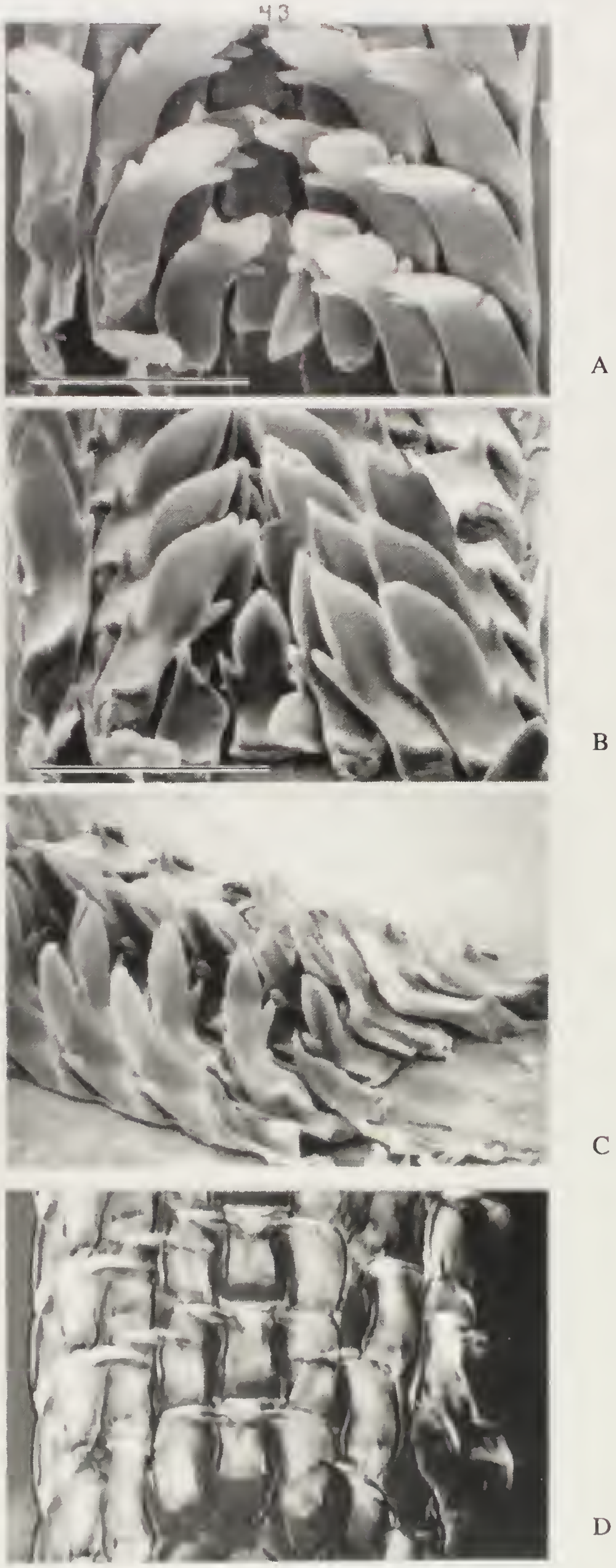
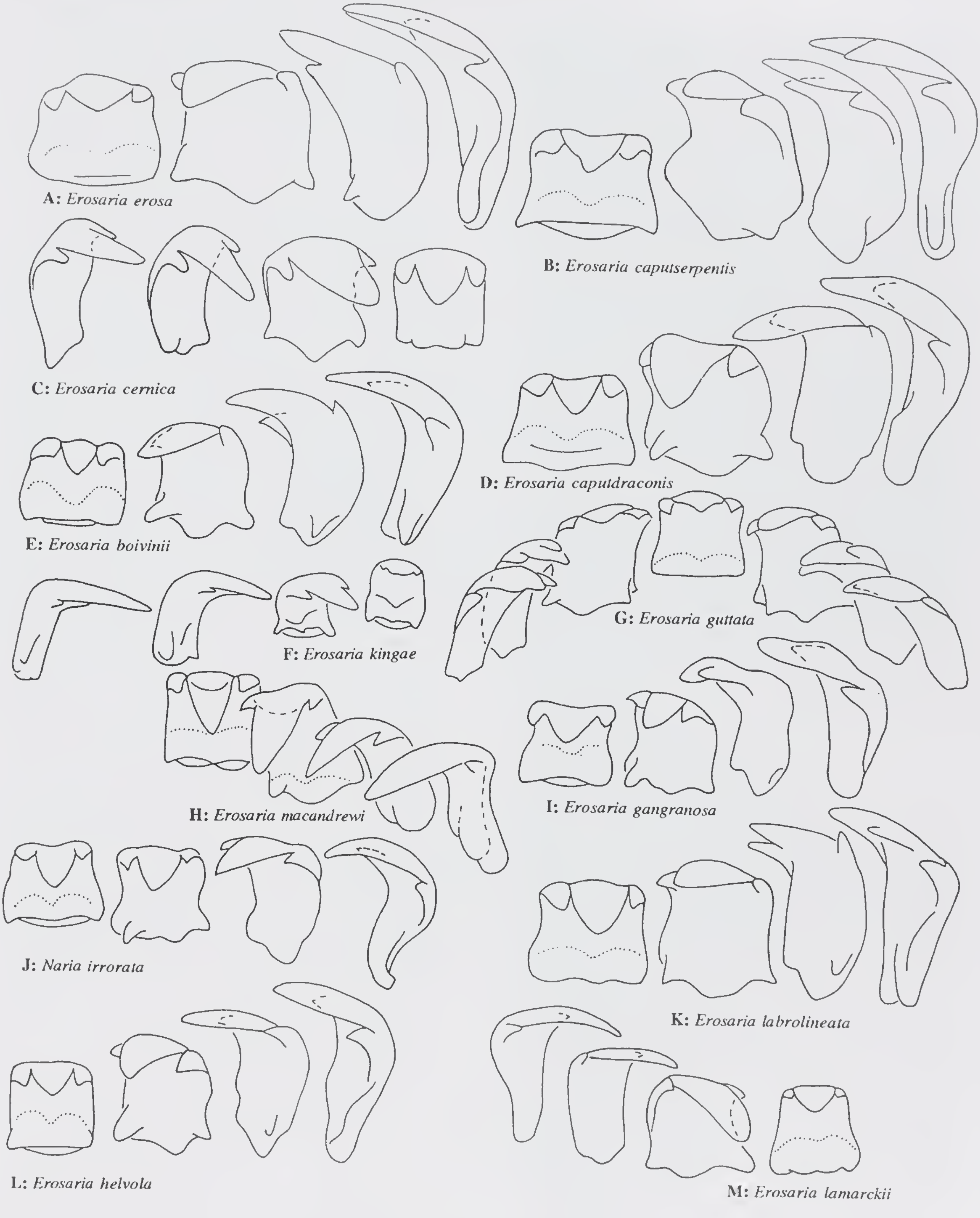


Figure 60. *Pustularia childreni*



A: *Erosaria erosa*

B: *Erosaria caputserpentis*

C: *Erosaria cernica*

D: *Erosaria caputdraconis*

E: *Erosaria boivinii*

F: *Erosaria kingae*

G: *Erosaria guttata*

H: *Erosaria macandrewi*

I: *Erosaria gangranosa*

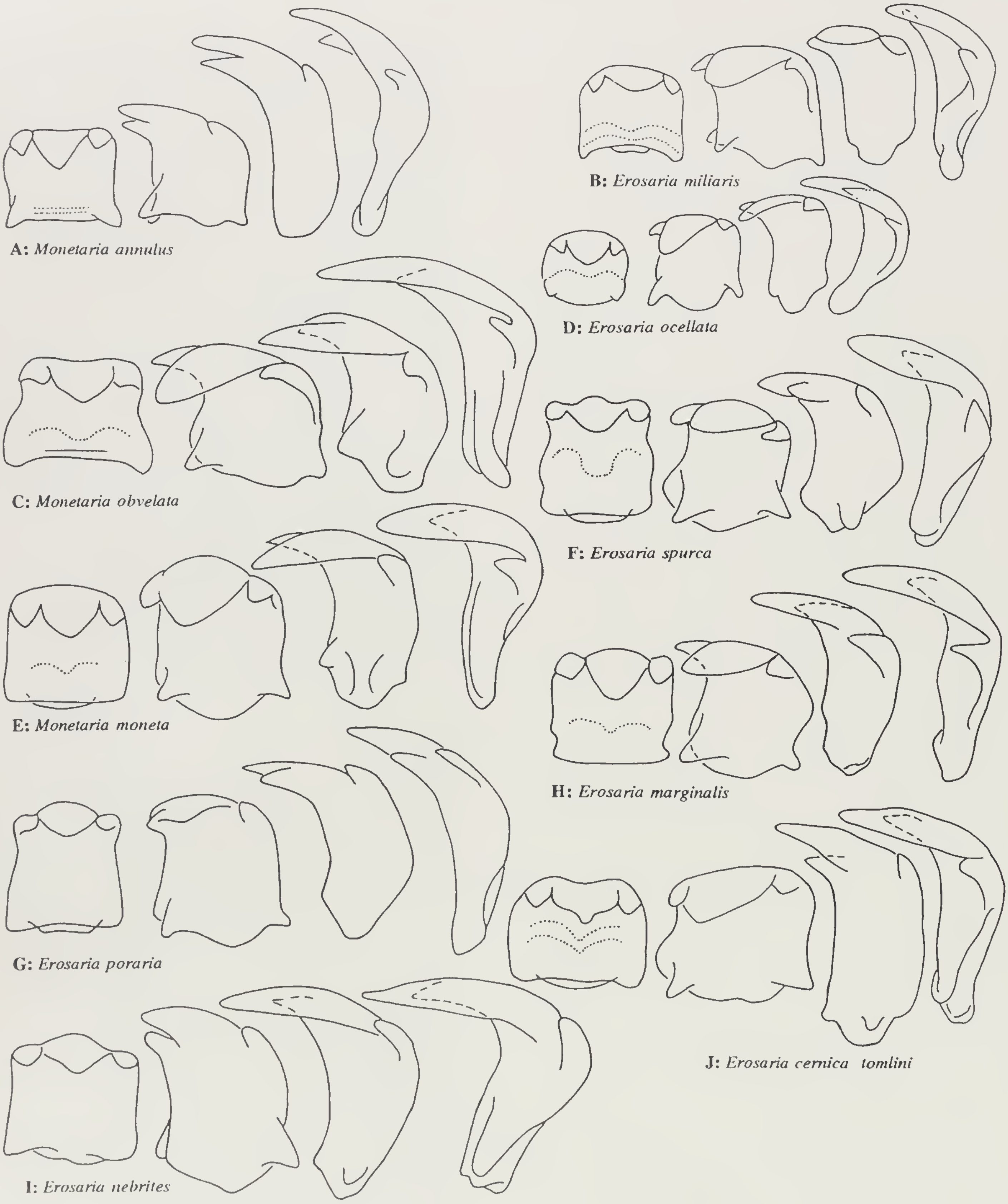
J: *Naria irrorata*

K: *Erosaria labrolineata*

L: *Erosaria helvola*

M: *Erosaria lamarckii*

Figure 61. Erosa pattern drawings I



A: *Monetaria annulus*

B: *Erosaria miliaris*

C: *Monetaria obvelata*

D: *Erosaria ocellata*

E: *Monetaria moneta*

F: *Erosaria spurca*

G: *Erosaria poraria*

H: *Erosaria marginalis*

I: *Erosaria nebrites*

J: *Erosaria cernica tomlini*

Figure 62. Erosa pattern drawings II

The Teres Pattern (Figures 63-69).

Model species: *Blasicrura teres* (Gmelin, 1791).

Species: *Blasicrura alisonae* (Burgess, 1983); *B. burgessi* (Kay, 1981); *B. latior* (Melvill, 1888); *B. rashleighana* (Melvill, 1888); *B. subteres* (Weinkauff, 1881); *B. teres* (Gmelin, 1791).

The bell-shaped central tooth and large lateral teeth, which dwarf the central tooth, characterize this cowrie radular pattern. The radular teeth are of medium size, with the central tooth in the 100 to 150 micron range (mean central tooth dimensions are 136x142 microns; n=8). The teeth are crowded, with the laterals and marginals overlapping. The shaft and cusps of the central tooth remain clear and transparent despite staining. The central tooth is tricuspid, curved on the anterior and basal edges, wider than long (mean length/width ratio 0.91; n=10), lateral cusps indented; and an internal bract present, but basal denticles absent. The laterals are tricuspid, 1.5 times the width of the central; the basal denticle is oriented toward the central. The marginals are wide, with bladelike cusps except in *B. rashleighana* and *B. subteres* where they are slender and overarch the laterals.

Central tooth dimensions 100x70 to 170x200 microns (n=8).

No. of radular rows: 61 to 80 (n=9).

No. radular rows per mm radula: 4.7 to 15.4 (n=10).

The teres pattern is here represented by six species in Iredale's (1930) genus *Blasicrura* as interpreted by M. Schilder & F. Schilder (1971). The shells are cylindrical to ovate, pale blue and blotched with brown, the fossula is narrow and ridged, and the animals are distinguished by a crimson mantle with sparse papillae and a bursa copulatrix in the females. The species occur in the Indo-West Pacific, and are also recorded from Panamá and the Islas Galápagos (*teres*) and Isla del Coco, Costa Rica (*alisonae*). Fossils are known from the late Pliocene of Indonesia.

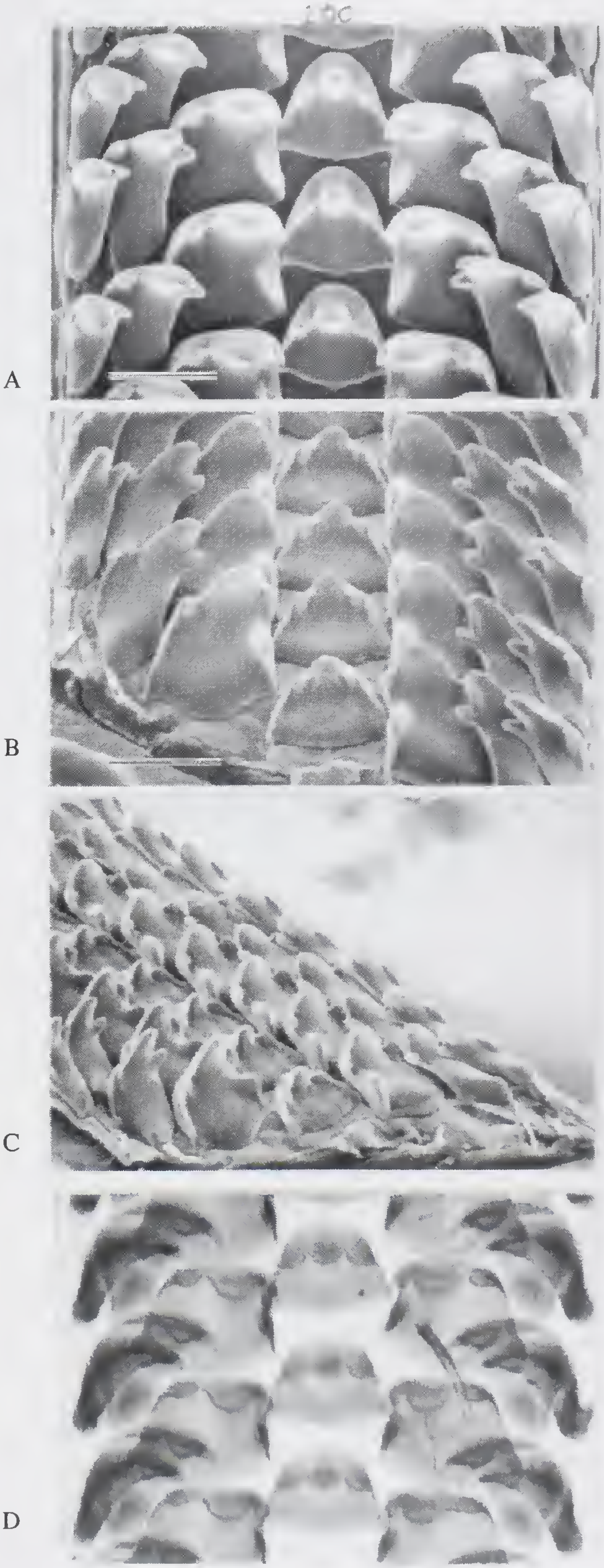


Figure 63. *Blasicrura teres*

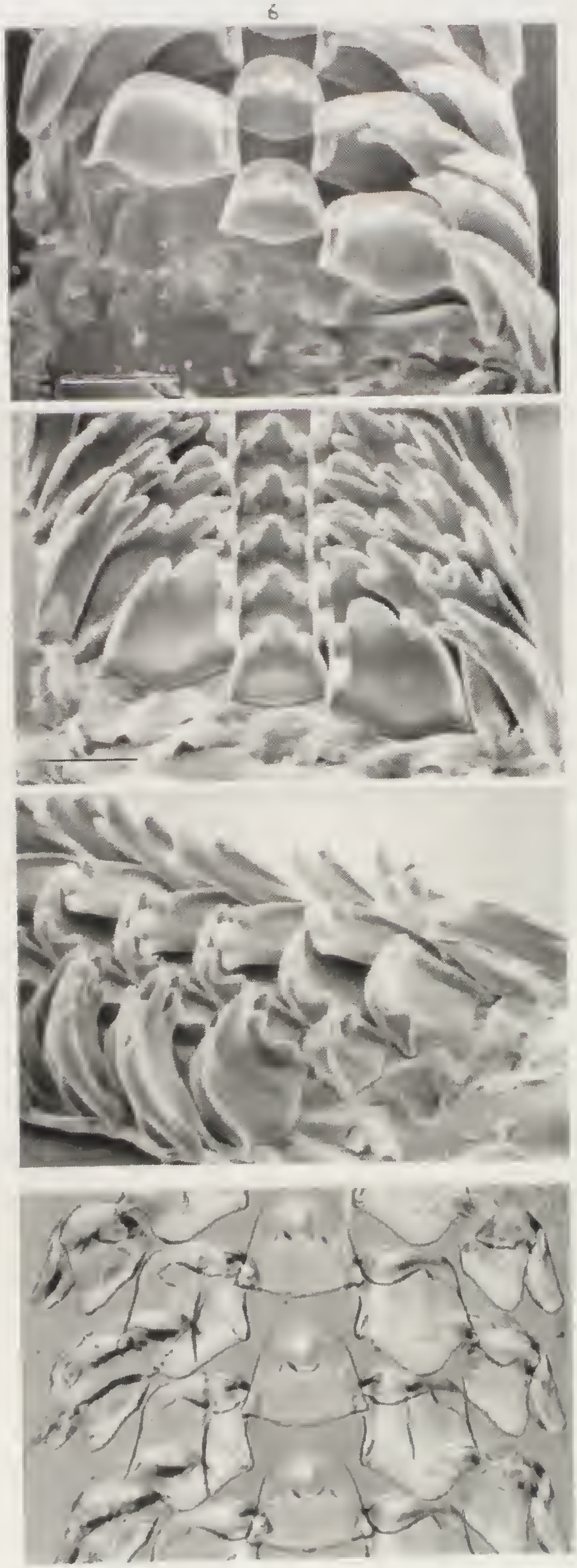


Figure 64. *Blasicrura alisonae*

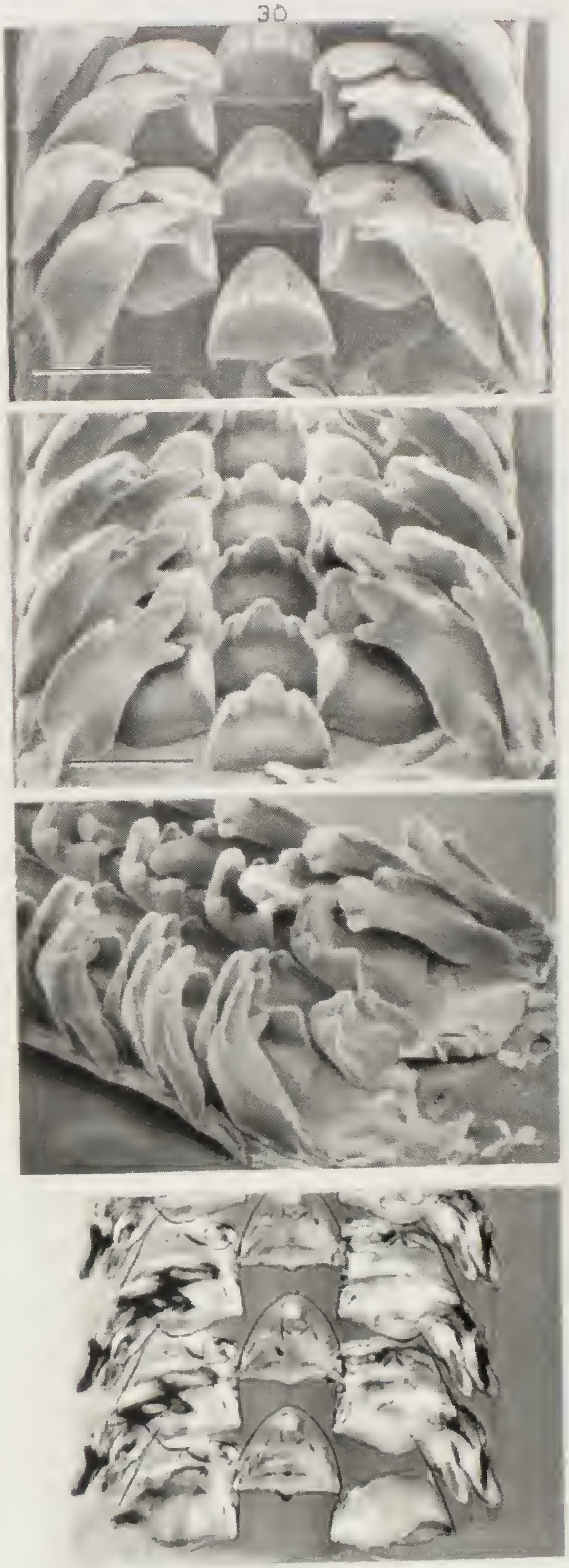


Figure 65. *Blasicrura burgessi*

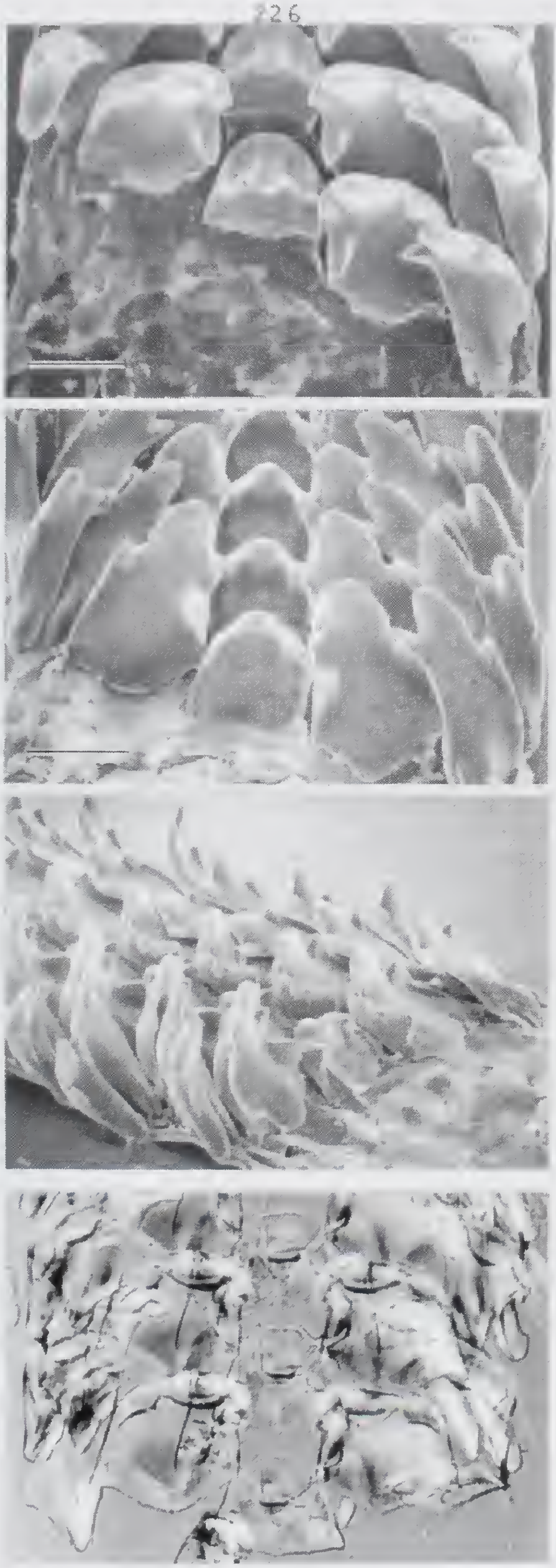


Figure 66. *Blasicrura latior*

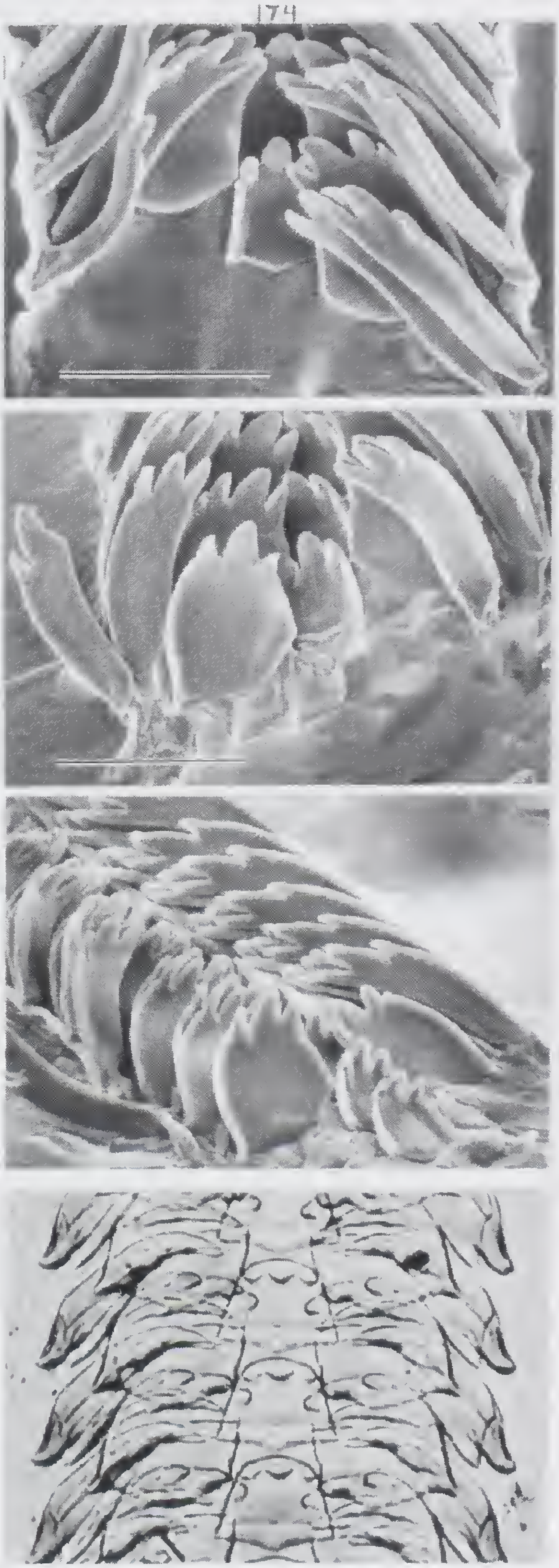


Figure 67. *Blasicrura rashleighana*

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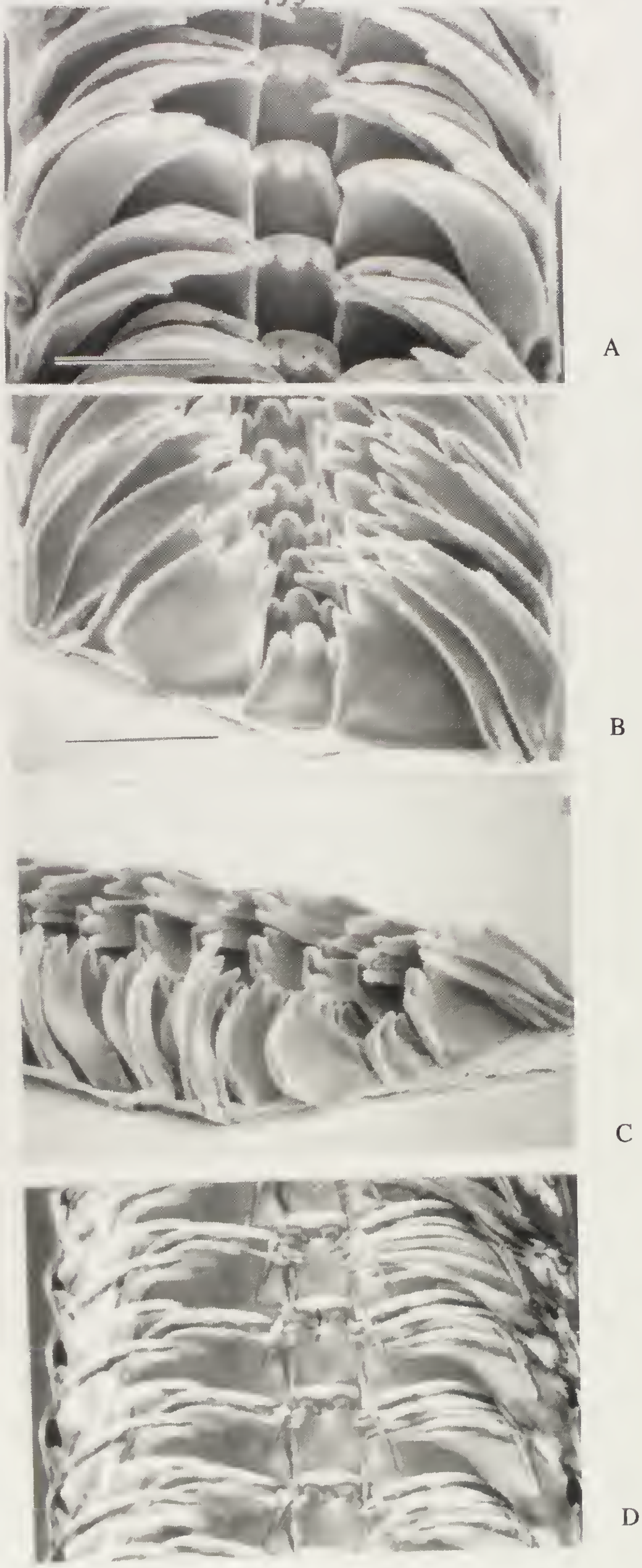
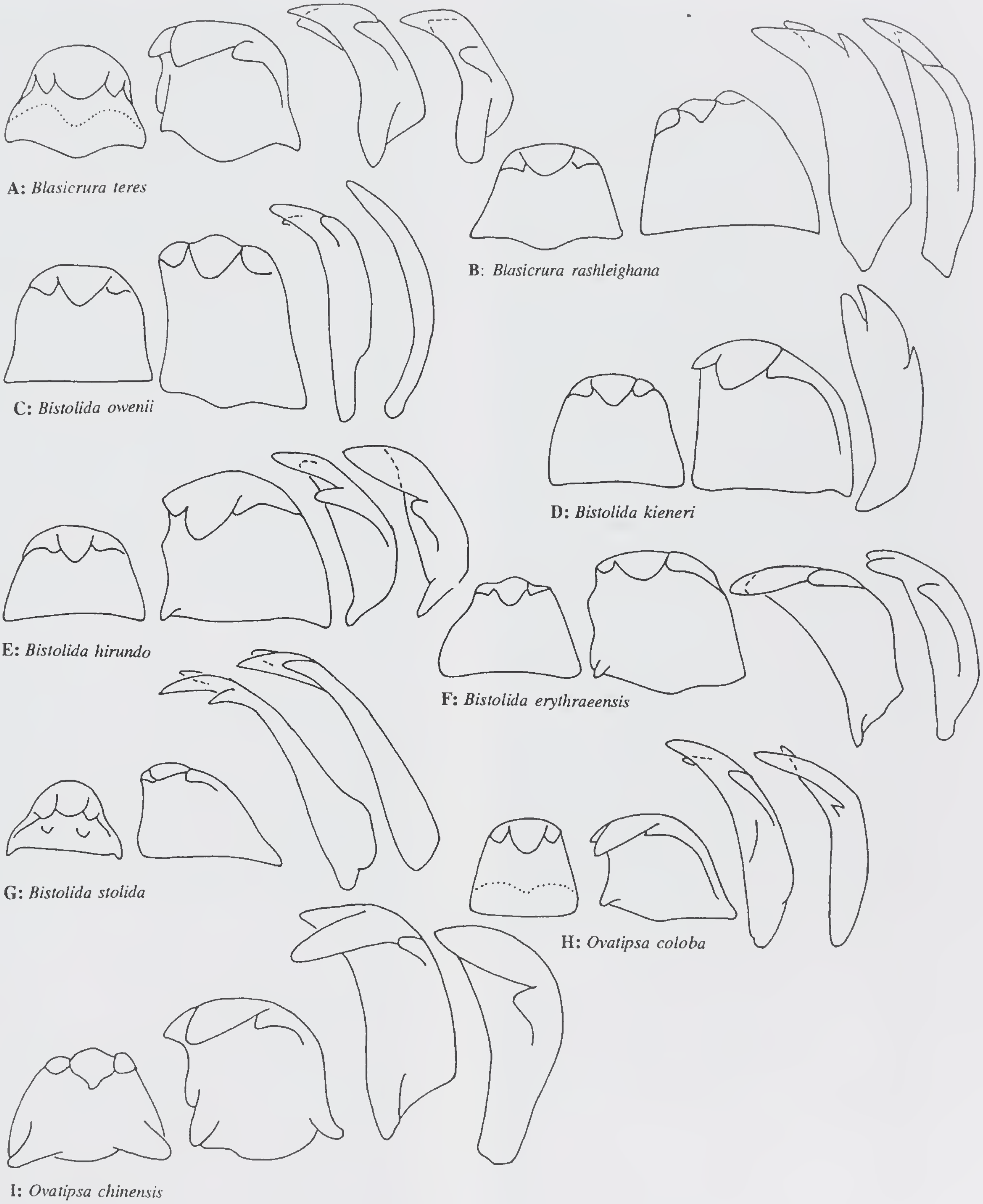


Figure 68. *Blasicrura subteres*



A: *Blasicrura teres*

B: *Blasicrura rashleighana*

C: *Bistolida owenii*

D: *Bistolida kieneri*

E: *Bistolida hirundo*

F: *Bistolida erythraeensis*

G: *Bistolida stolida*

H: *Ovatipsa coloba*

I: *Ovatipsa chinensis*

Figure 69. Teres & Stolida pattern drawings

The Stolida Pattern (Figures 69-77).
Model species: *Bistolida stolida* (Linnaeus, 1758).

Species: *Bistolida erythraeensis* (Sowerby, 1837); *B. hirundo* (Linnaeus, 1758); *B. kieneri* (Hidalgo, 1906); *B. owenii* (Sowerby, 1837); *B. stolida* (Linnaeus, 1758); *B. ursellus* (Gmelin, 1791); *Ovatipsa chinensis* (Gmelin, 1791); *O. coloba* (Melvill, 1888).

The radular teeth in these cowries, although seemingly similar to those of the teres pattern, are distinguished by the cowl-shaped central tooth which bears paired mid-shaft denticles, and is smaller in size than in six species of *Bistolida* (mean central tooth dimensions are 54.4x68.5 microns (n=8) for *Bistolida*), although the central tooth in *Ovatipsa* is in the 110 to 150 micron range. As in the teres pattern, the teeth are crowded and overlapping and remain clear and transparent despite staining. The marginals are wide, with bladelike cusps except in *B. erythraeensis* and *B. stolida* where they are slender, even sickle-like.

Central tooth dimensions: 40x70 to 75x80 microns (n=10) in *Bistolida*; 130x135 microns (n=3) in *Ovatipsa*.
No. of radular rows: 56 to 90 (n=2).
No. radular rows per mm radula length: 10.6 to 31.7 (n=9) in *Bistolida*; 6.4 to 13.6 (n=3) in *Ovatipsa*.

The stolida pattern includes the six species of *Bistolida* Cossmann, 1920, as interpreted by M. Schilder and F. Schilder (1971), and the two species of *Ovatipsa* Iredale, 1931. The shells are ovate to cylindrical, the dorsum is of some tint of blue, the fossula is straight and ribbed, and a bursa copulatrix is present in the females of *Bistolida* but absent in *Ovatipsa*. These species are found only in the Indo-West Pacific. There are fossil records of *Ovatipsa* in the late Miocene of Indonesia, but fossils of *Bistolida* have not been reported.

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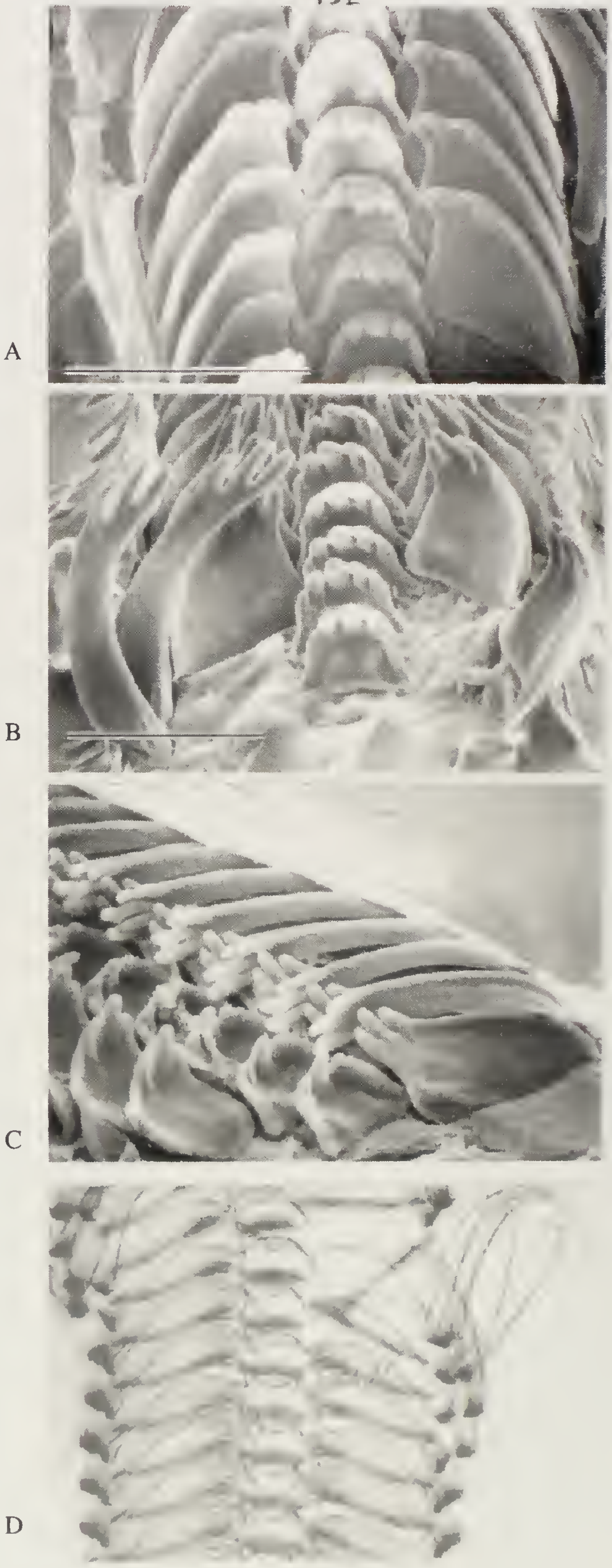

Figure 70. *Bistolida stolida*

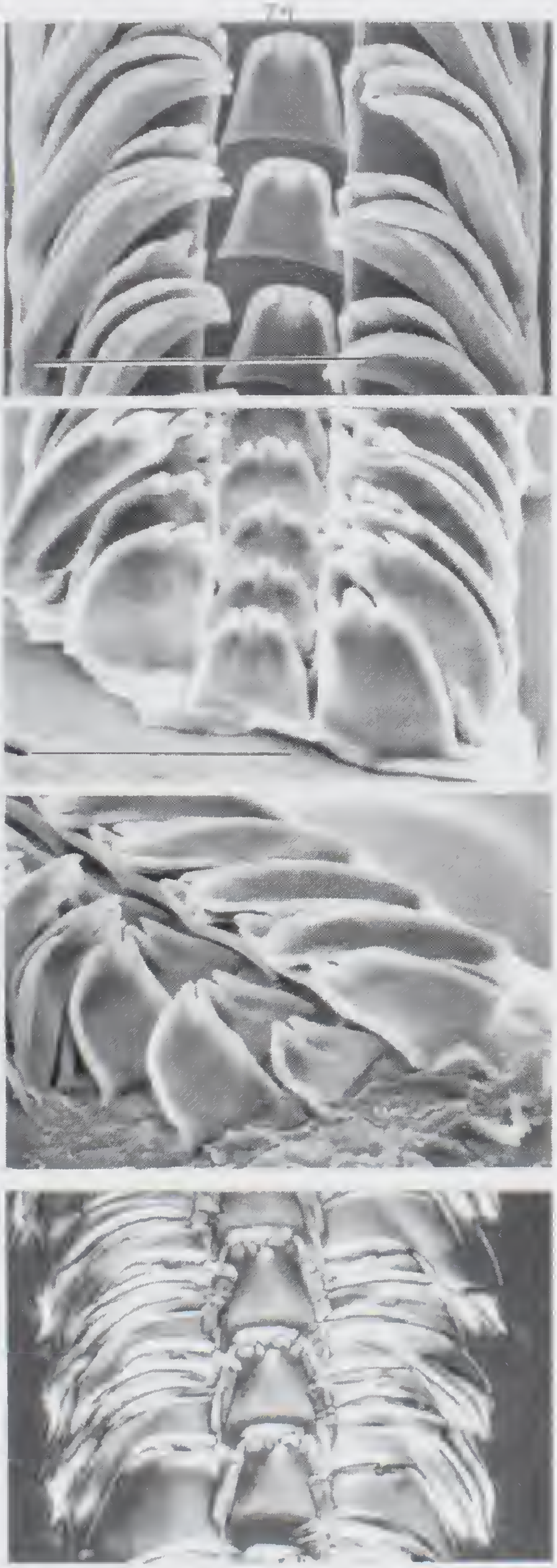

Figure 71. *Bistolida erythraeensis*

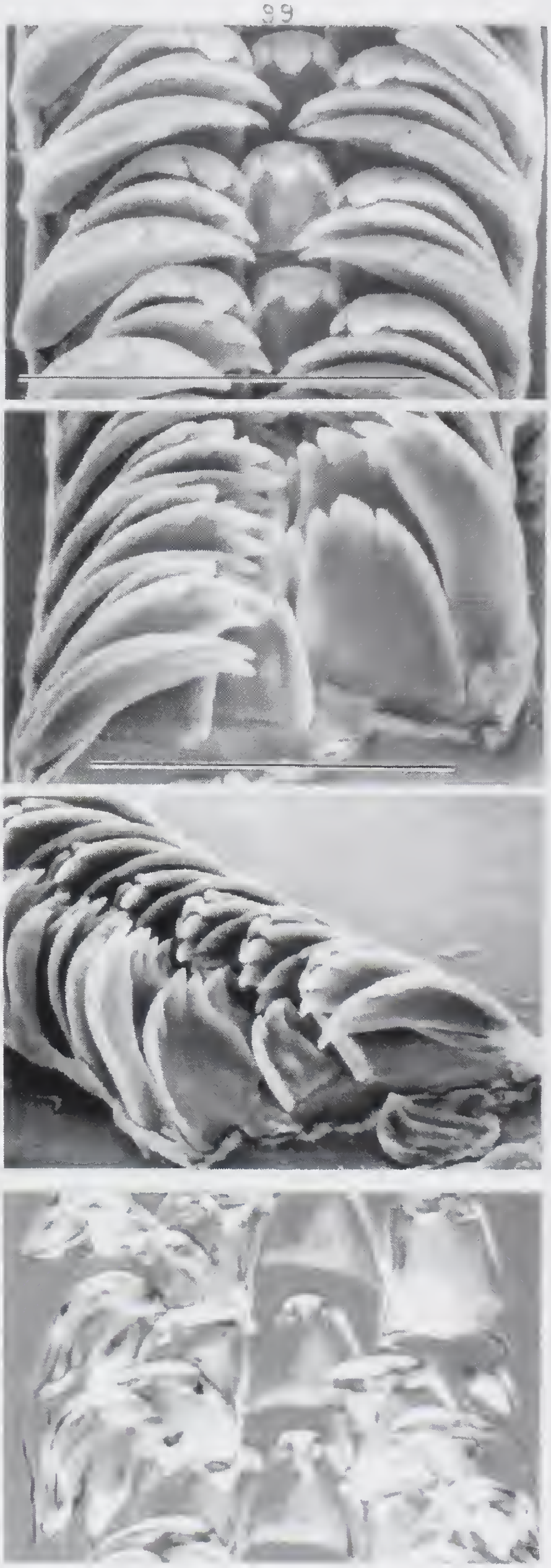

Figure 72. *Bistolida hirundo*

111

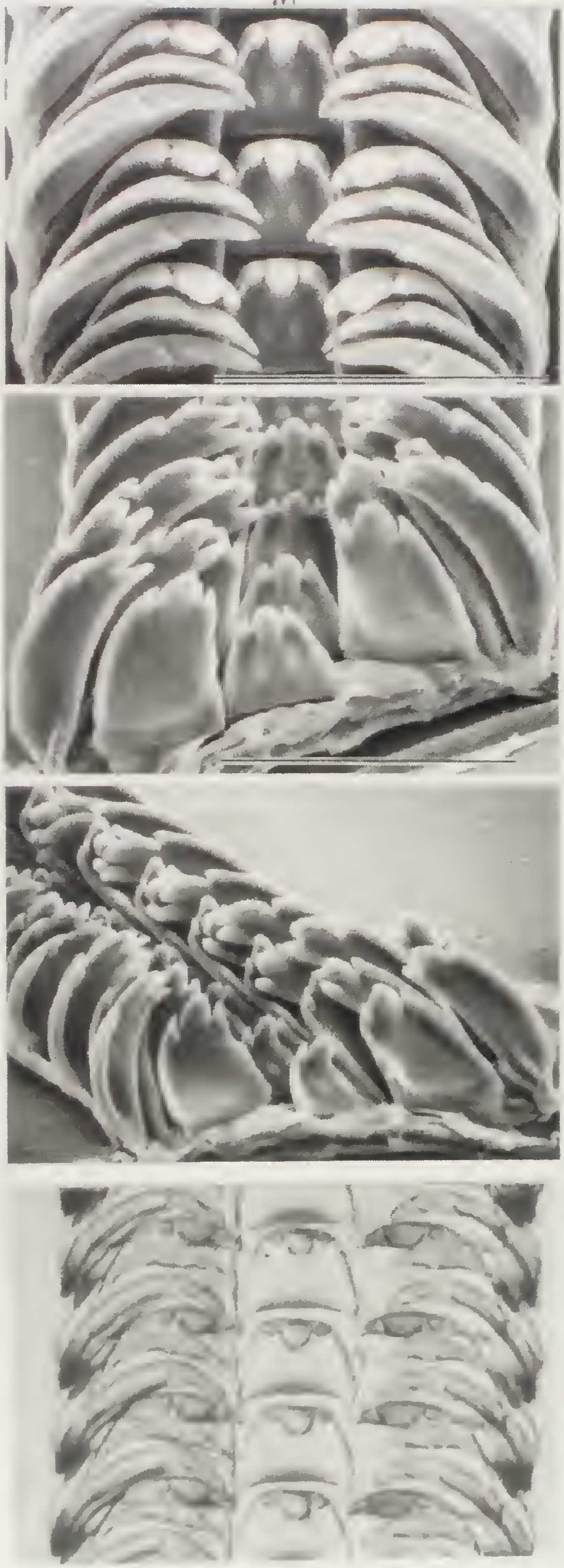

Figure 73. *Bistolida kieneri*

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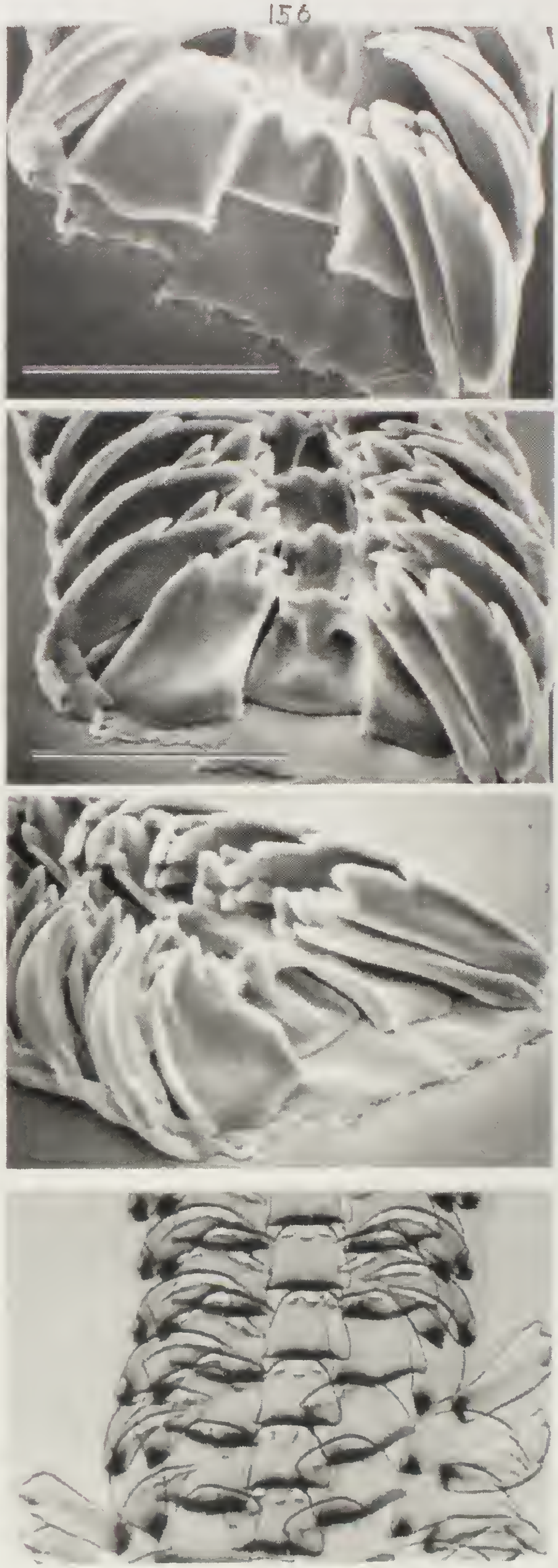

Figure 74. *Bistolida owenii*

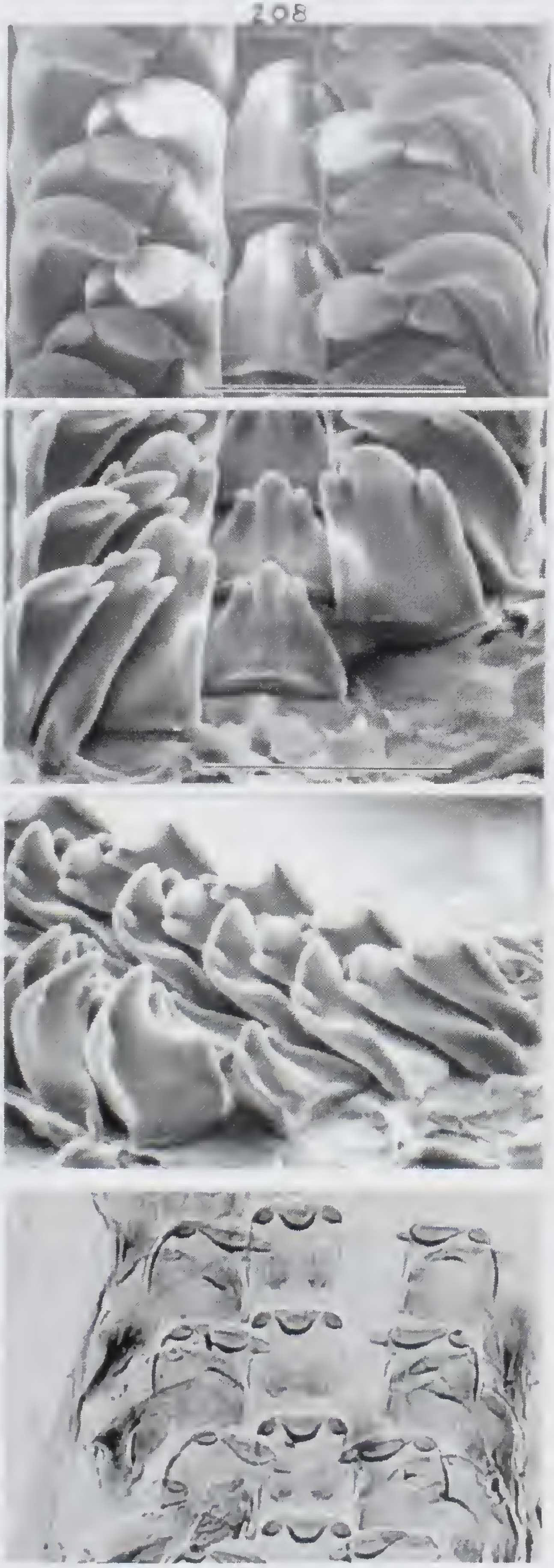

Figure 75. *Bistolida ursellus*

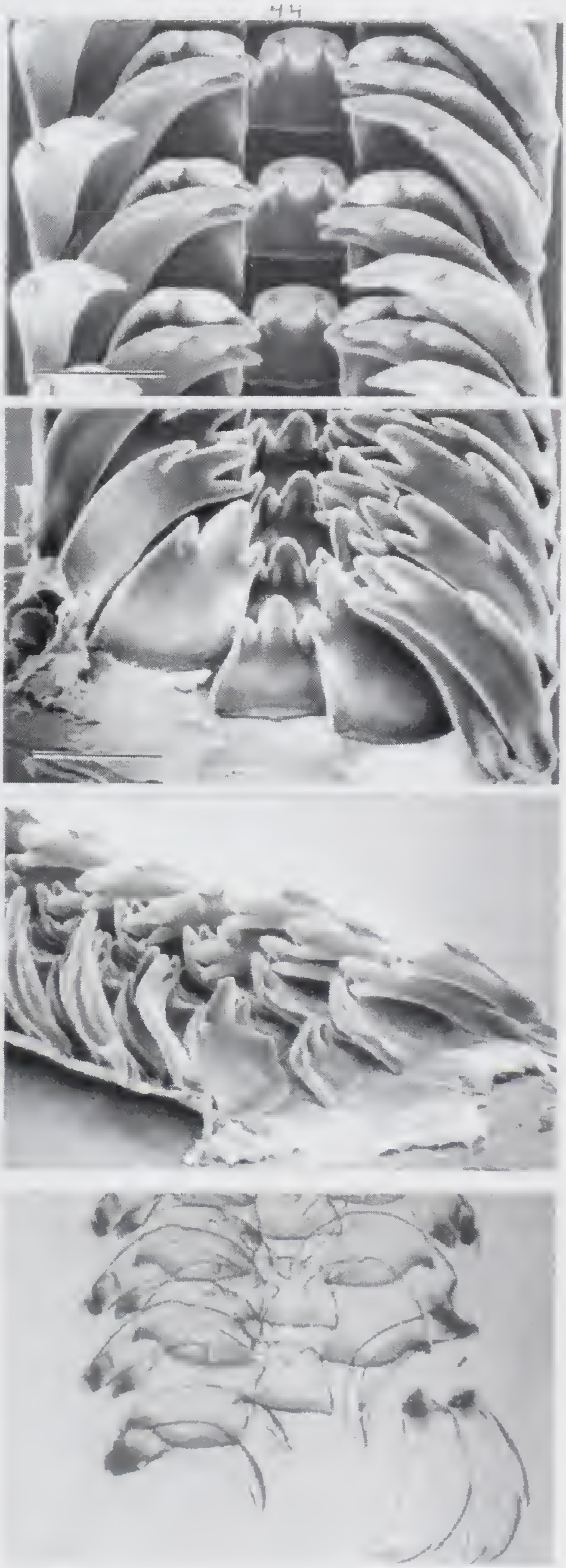

Figure 76. *Ovatipsa chinensis*

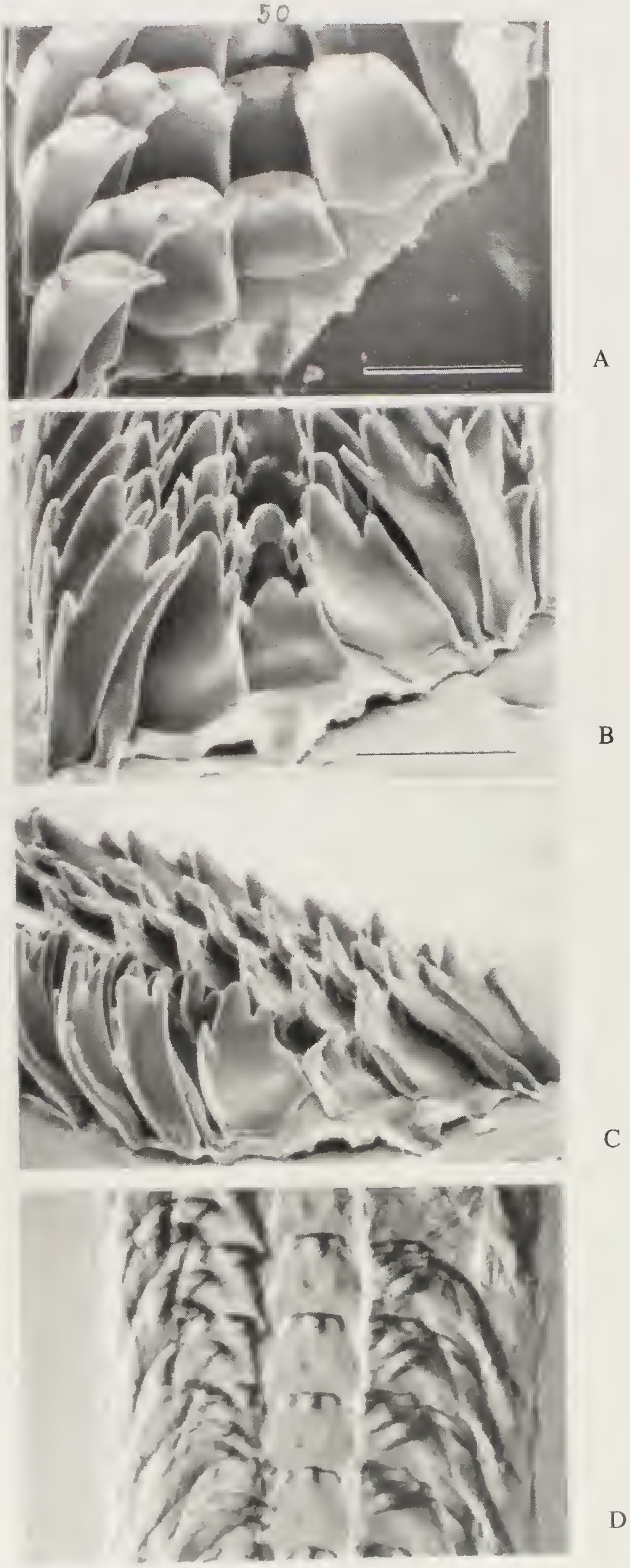

Figure 77. *Ovatipsa coloba*

The Errones Pattern (Figures 1, 8, 9, 78-105).
Model Species: *Erronea errones* (Linnaeus, 1758).

Species: Blasicrura coxeni (Cox, 1873); *B. dayritiana* (Cate, 1963); *B. luchuana* (Kuroda, 1960); *B. quadrimaculata* (Gray, 1824); *Erronea* (*Erronea*) *caurica* (Linnaeus, 1758); *E.* (*E.*) *cylindrica* (Born, 1778); *E.* (*E.*) *errones* (Linnaeus, 1758); *E.* (*E.*) *felina* (Gmelin, 1791); *E.* (*E.*) *ovum* (Gmelin, 1791); *E.* (*Adusta*) *barclayi* (Reeve, 1857); *E.* (*A.*) *bregeriana* (Crosse, 1868); *E.* (*A.*) *hungerfordi* (Sowerby, 1888); *E.* (*A*) *lisetae* (Kilburn, 1975); *E.* (*A.*) *onyx* (Linnaeus, 1758); *E.* (*A.*) *pallida* (Gray, 1824); *E.* (*A.*) *pulchella* (Swainson, 1823); *E.* (*A.*) *pyriformis* (Gray, 1824); *E.* (*A.*) *subviridis* (Reeve, 1835); *E.* (*A.*) *vredenburgi* Schilder, 1927; *E.* (*A.*) *walkeri* (Sowerby, 1832); *E.* (*A.*) *xanthodon* (Sowerby, 1832); *Notadusta katsuae* (Kuroda, 1960); *N. martini* (Schepman, 1907); *N. punctata* (Linnaeus, 1771); *N. rabaulensis* Schilder, 1964.

The distinctive feature of the errones pattern is the pair of prominent, sometimes pendulous, denticles which emerge mid-shaft on the central tooth and often project beyond the basal platform. The teeth are small to medium in size (mean dimensions of the central tooth, about 112x97 microns (n=28) in *Erronea*, 97x75 microns (n=3) in *Blasicrura*, and 85x65 microns (n=6) in *Notadusta*), crowded with densely overlapping laterals and marginals but with the central tooth usually exposed. The central tooth is tricuspid, with an internal bract but no subtending bract. The laterals are about the same size as the central, each with a basal denticle oriented toward the central tooth. The marginals are bladelike with narrow bases. Figures 101 & 102 show two distinctly different forms of teeth of *Notadusta punctata*.

Central tooth dimensions: 85x50 to 105x75 microns (n=3) in *Blasicrura*; 65x55 to 155x115 microns (n=28) in *Erronea*; 70x65 to 125x75 microns (n=3) in *Notadusta*.
No. of radular rows: 85 to 153 (n=13) in *Erronea*.
No. radular rows per mm of radula: 16 to 18 in *Blasicrura* (n=2); 6 to 22 (n=24) in *Erronea*; 14 to 20 in *Notadusta* (n =4).

All of the cowries with this pattern of radular teeth are found in the Indo-West Pacific: the 16 species assigned to *Erronea* by M. Schilder and F. Schilder, (1971) plus three of the four species of *Notadusta* and four species of *Blasicrura*. They are all characterized by tan to brown shells about 20 mm in length, with a shallow, ridged fossula. The mantles are dark-colored with branched papillae, and the females lack a bursa copulatrix. Fossils of *Blasicrura* are known from the Pliocene of Indonesia. *Erronea* and *Notadusta* are reported from the early Miocene of Enewetak, Marshall Islands and New Zealand respectively.

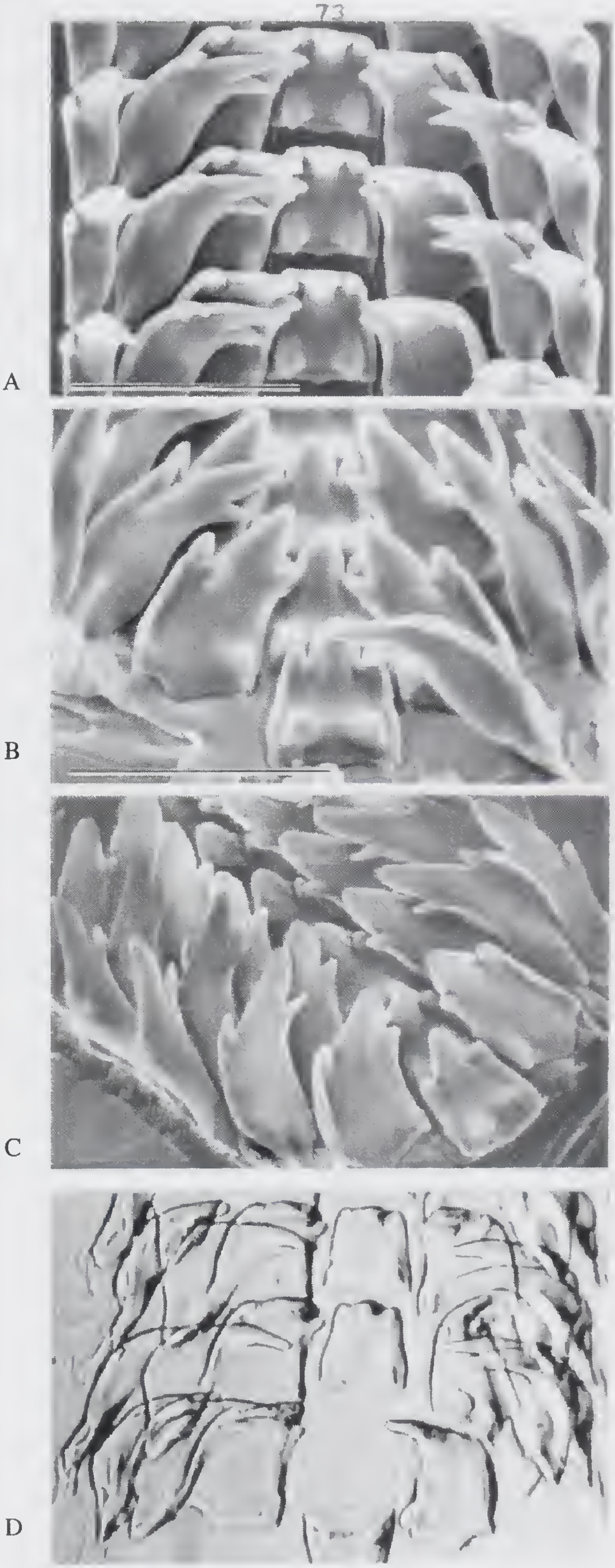

Figure 78. *Erronea errones*

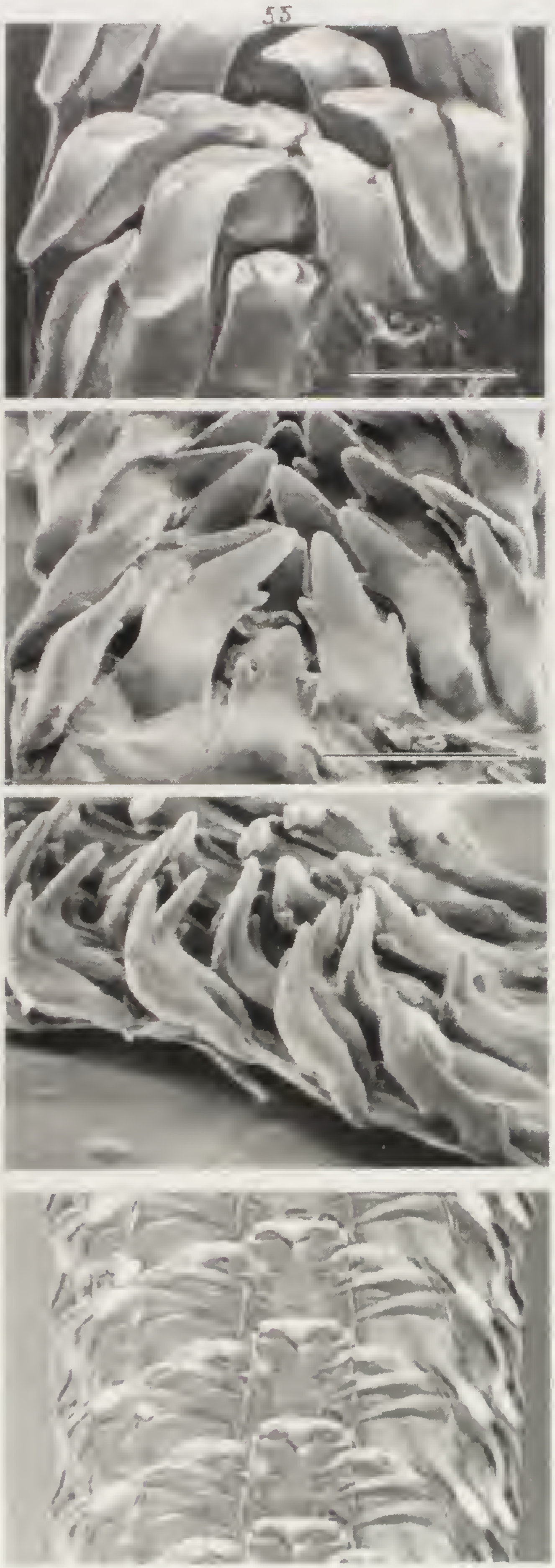

Figure 79. *Blasicrura coxeni*

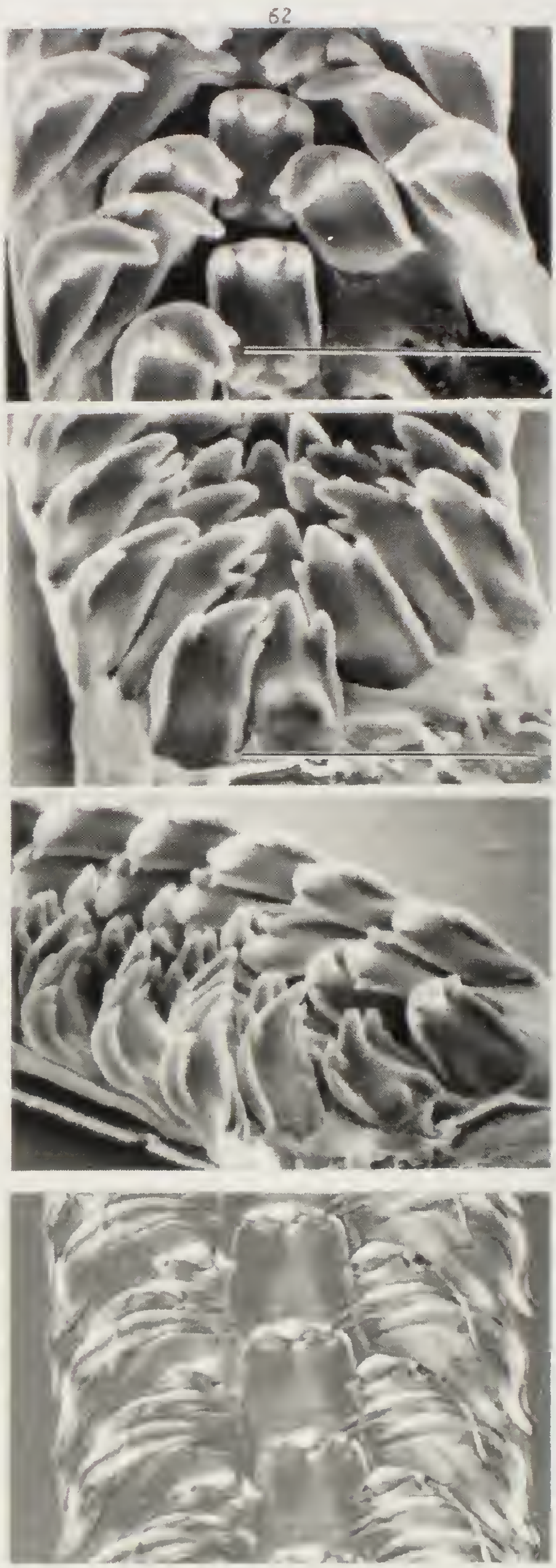

Figure 80. *Blasicrura dayritiana*

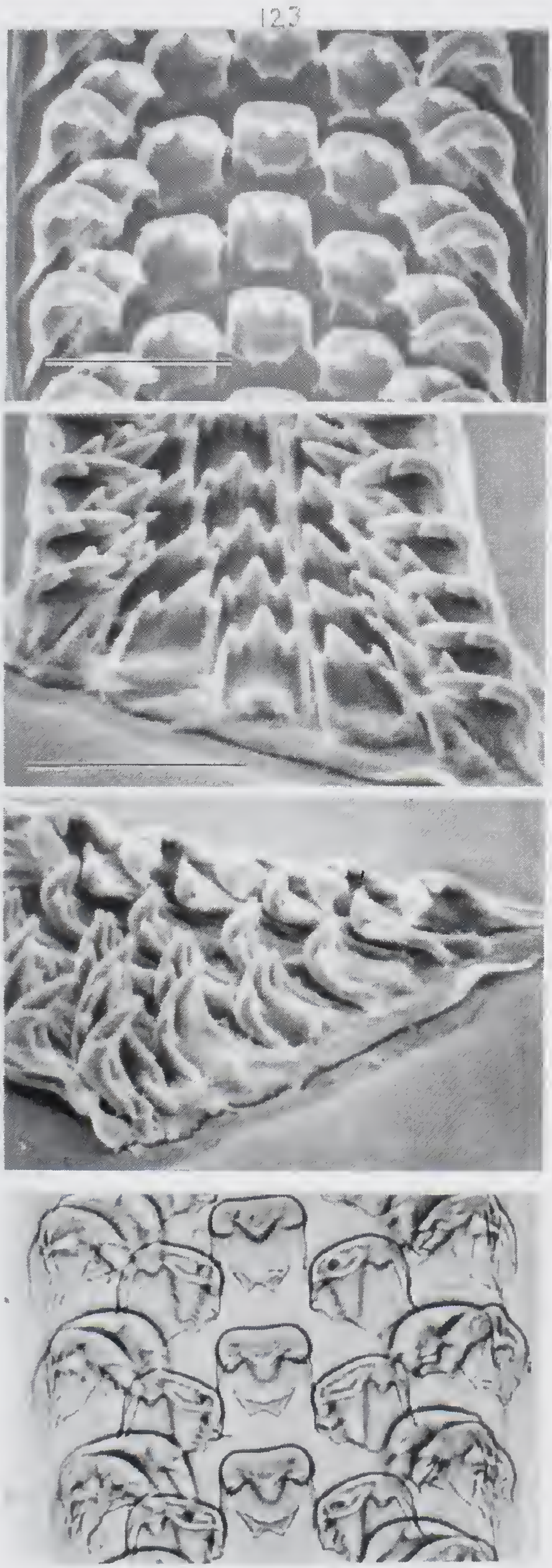

Figure 81. *Blasicrura luchuana*

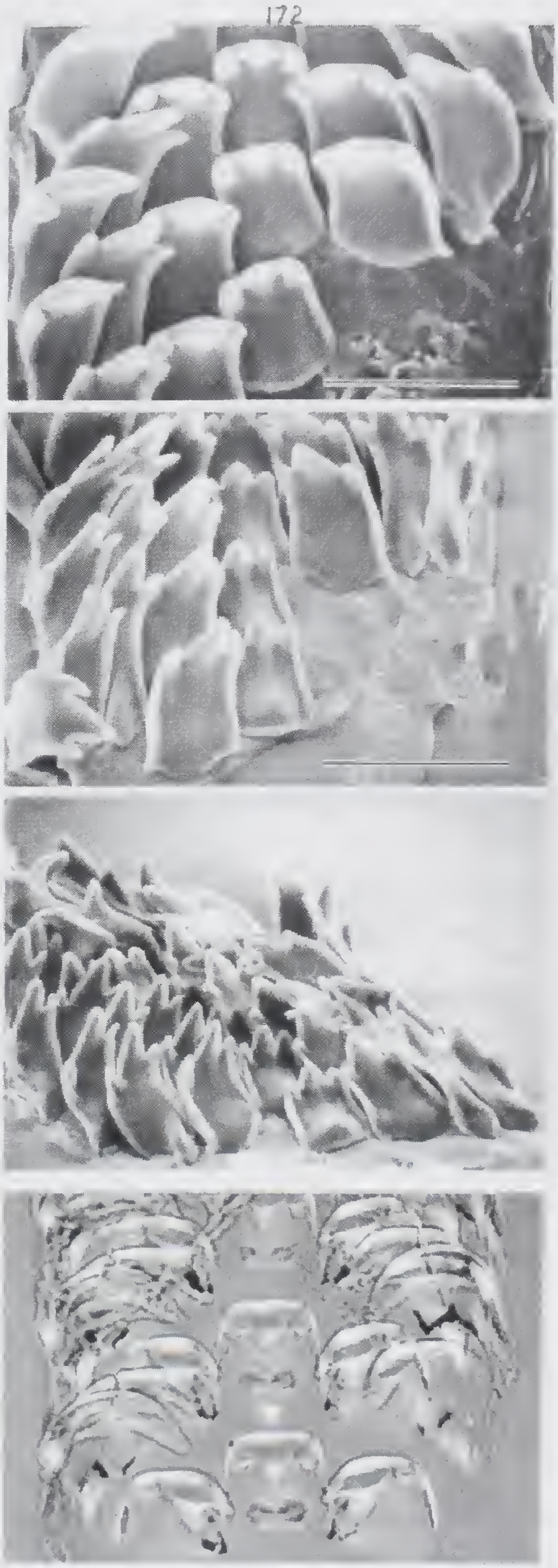

Figure 82. *Blasicrura quadrimaculata*

39

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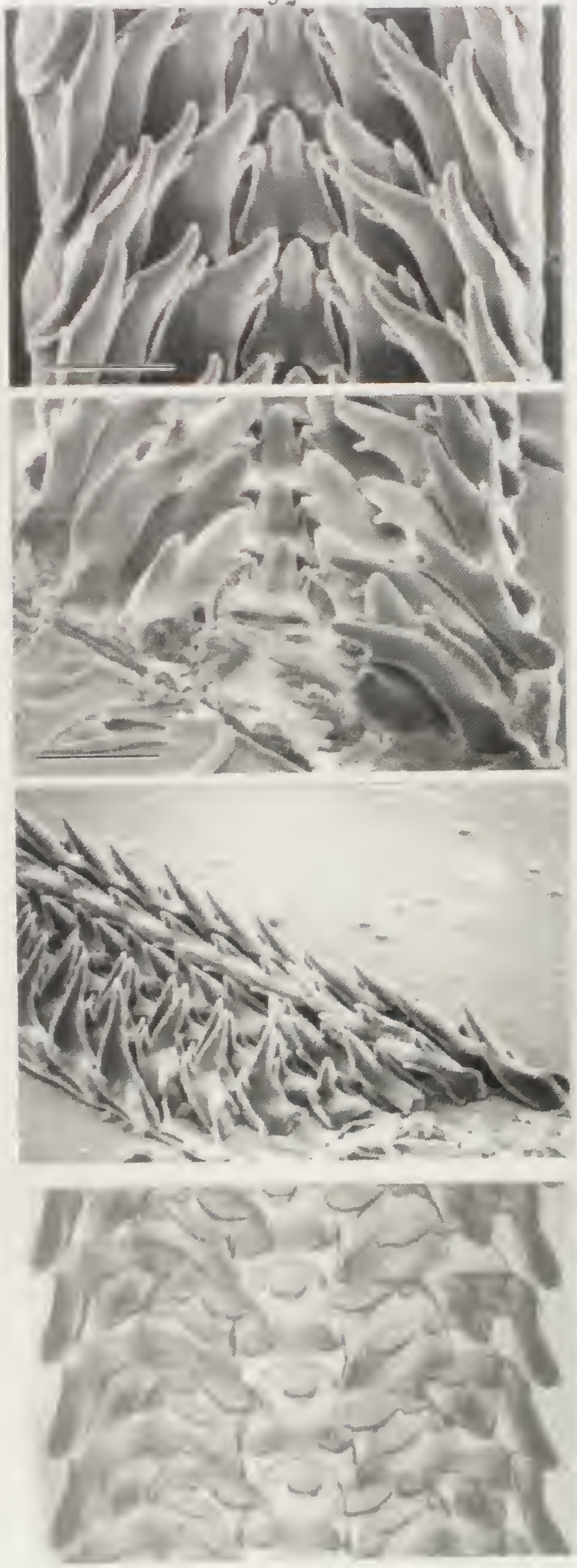


Figure 83. *Erronea caurica*

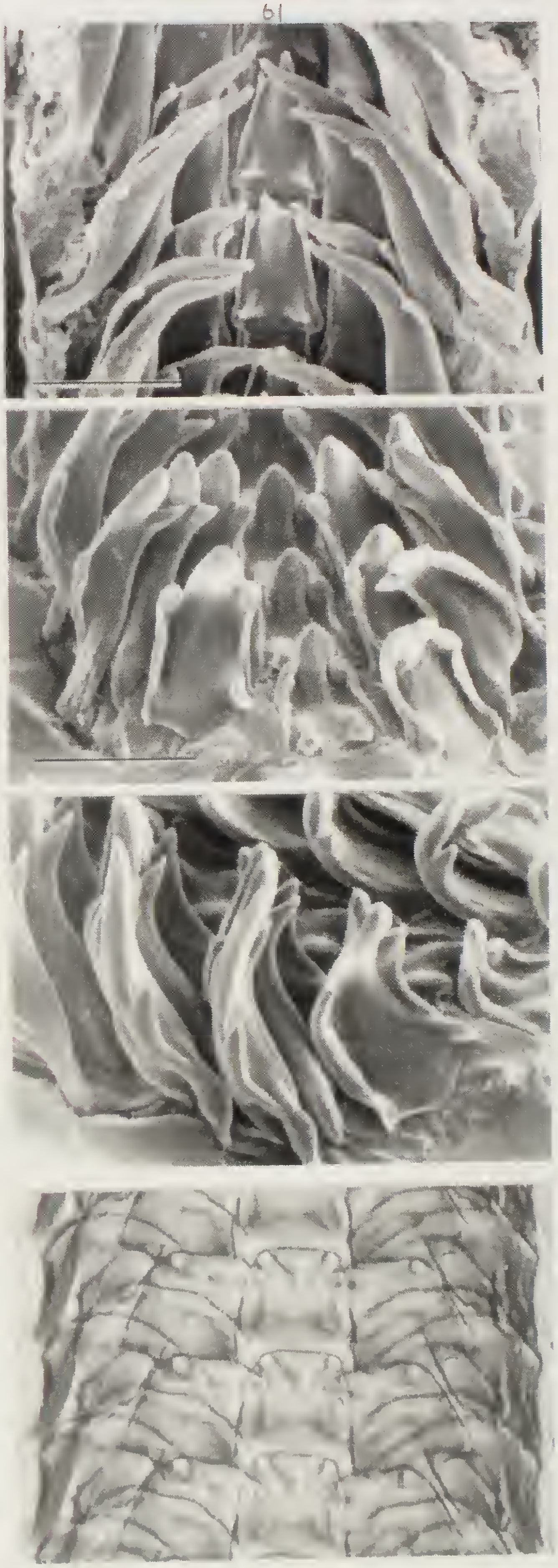


Figure 84. *Erronea cylindrica*

78

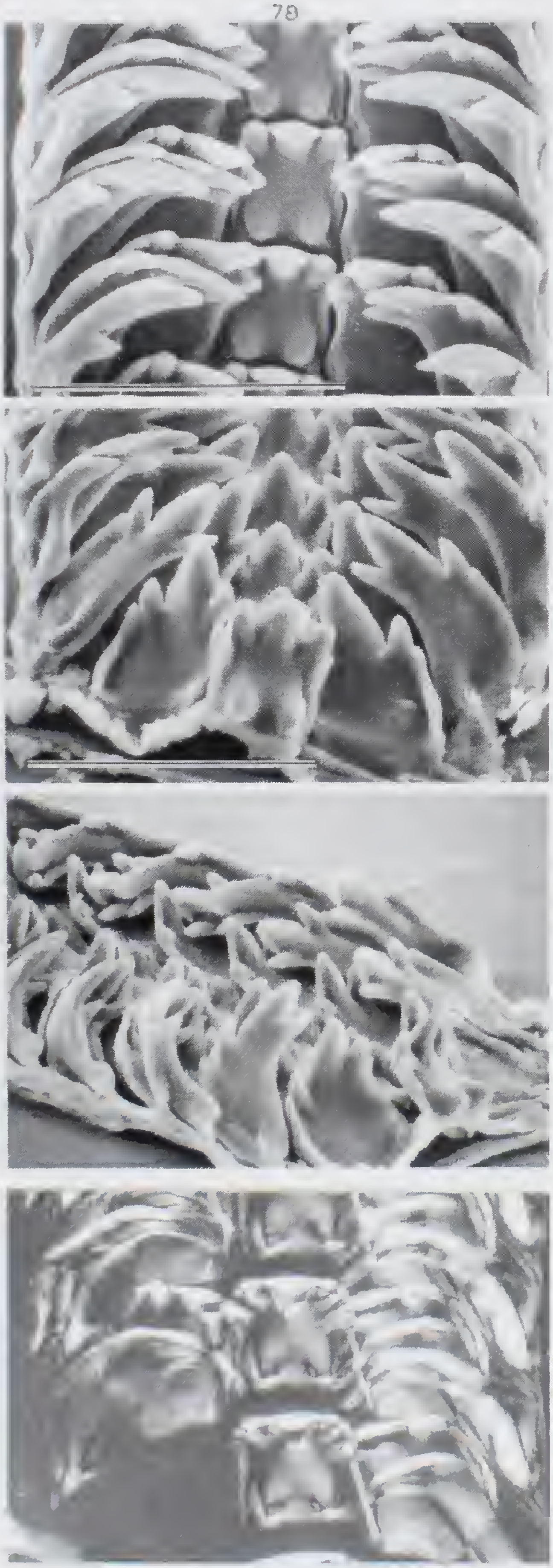


Figure 85. *Erronea felina*

155

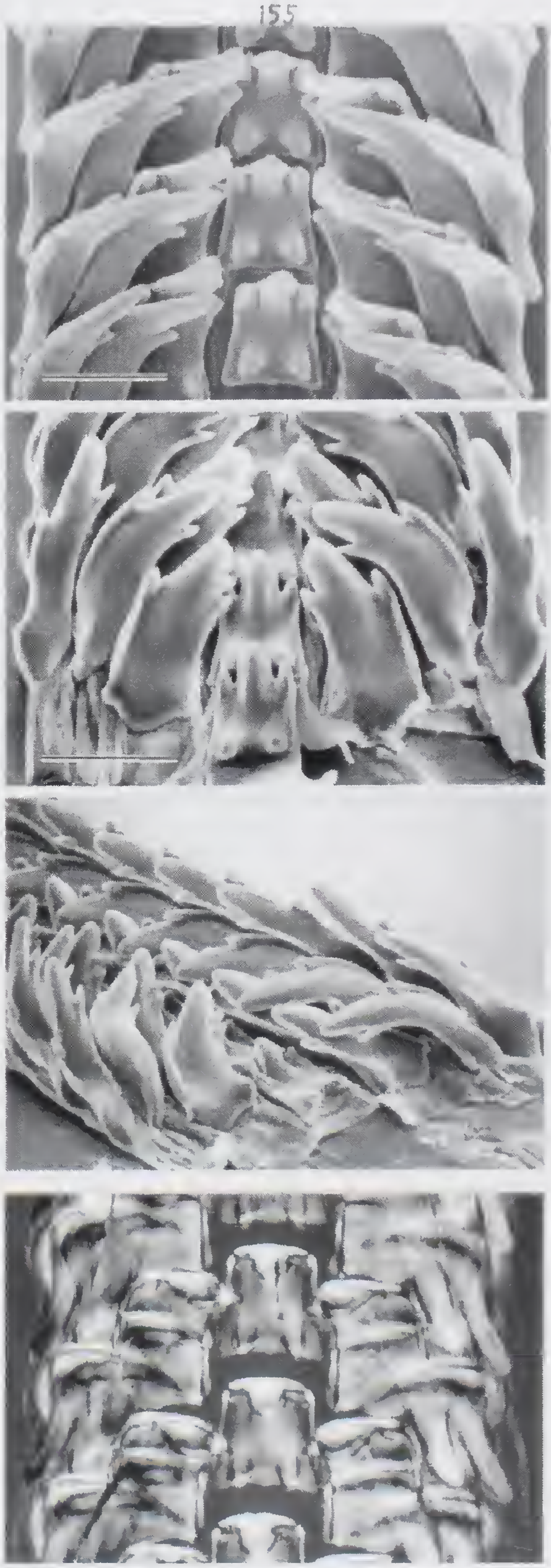


Figure 86. *Erronea ovum*

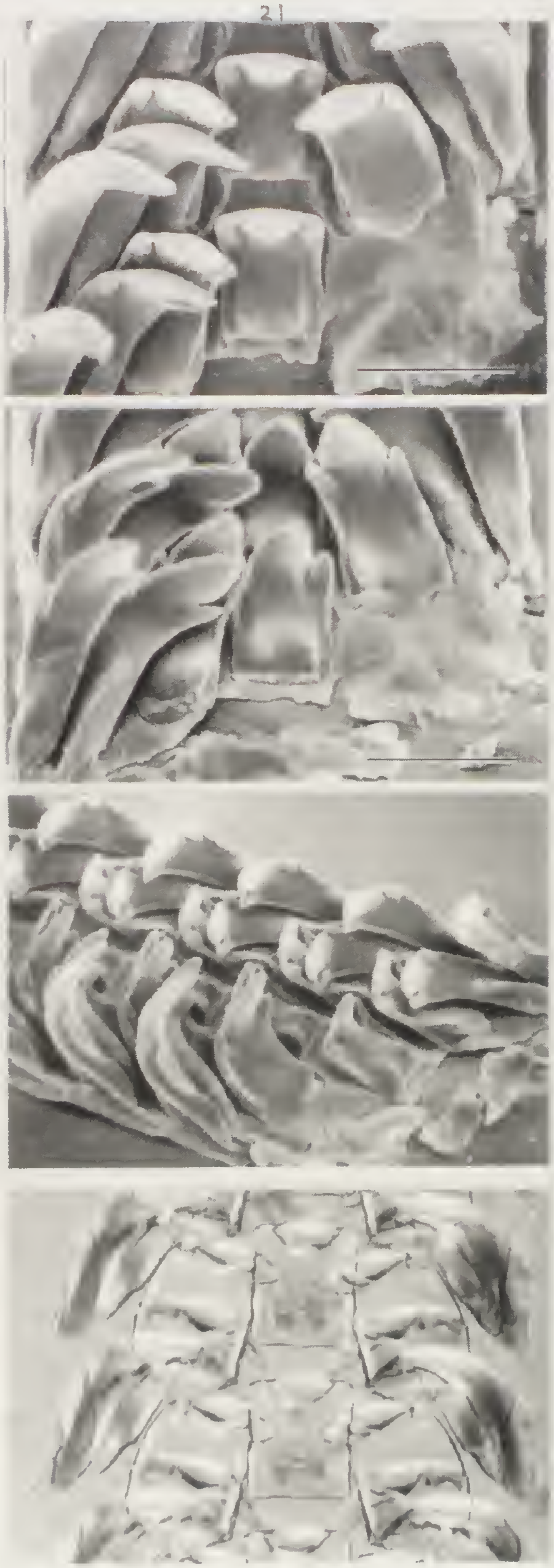


Figure 87. *Erronea barclayi*

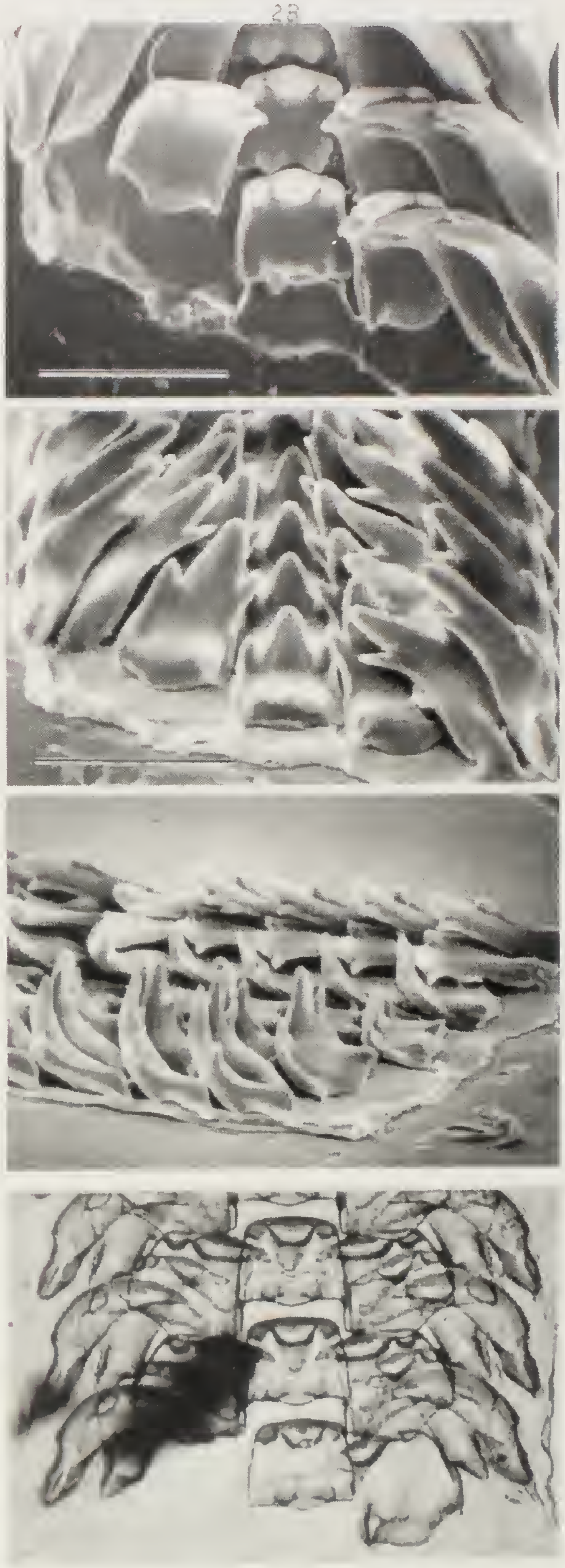


Figure 88. *Erronea bregeriana*

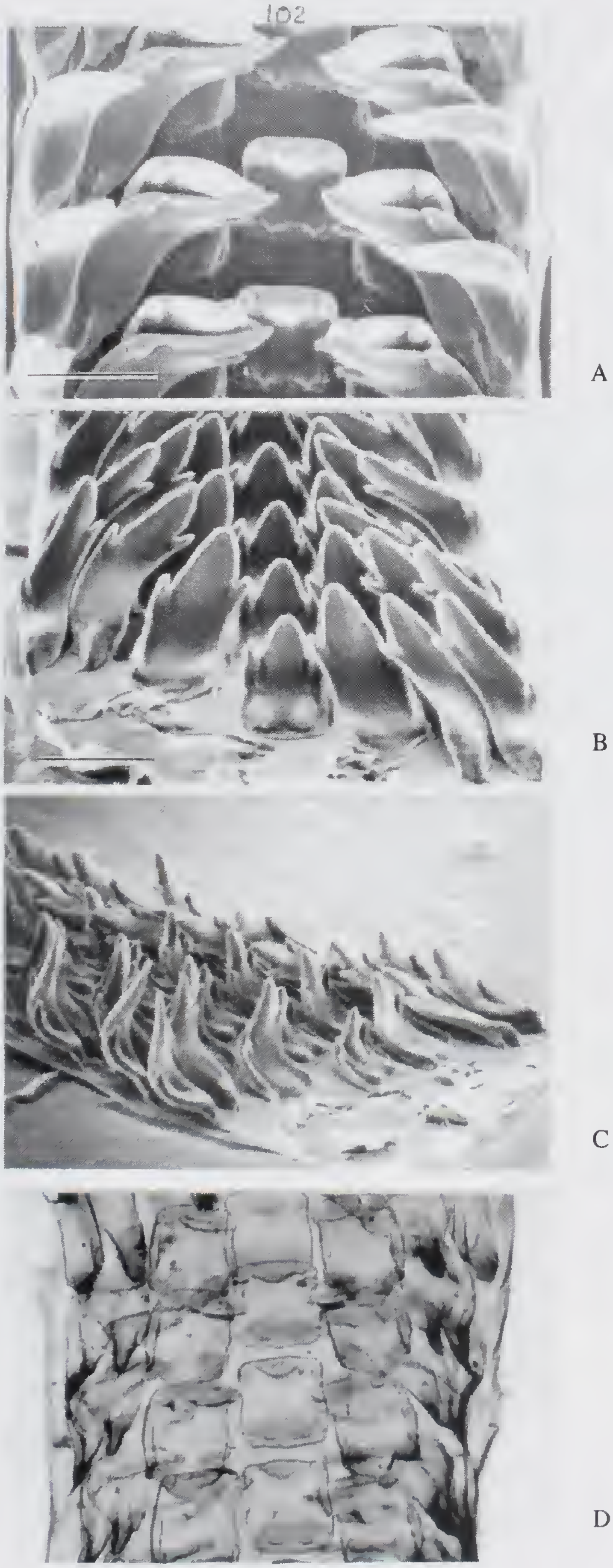


Figure 89. *Erronea hungerfordi*

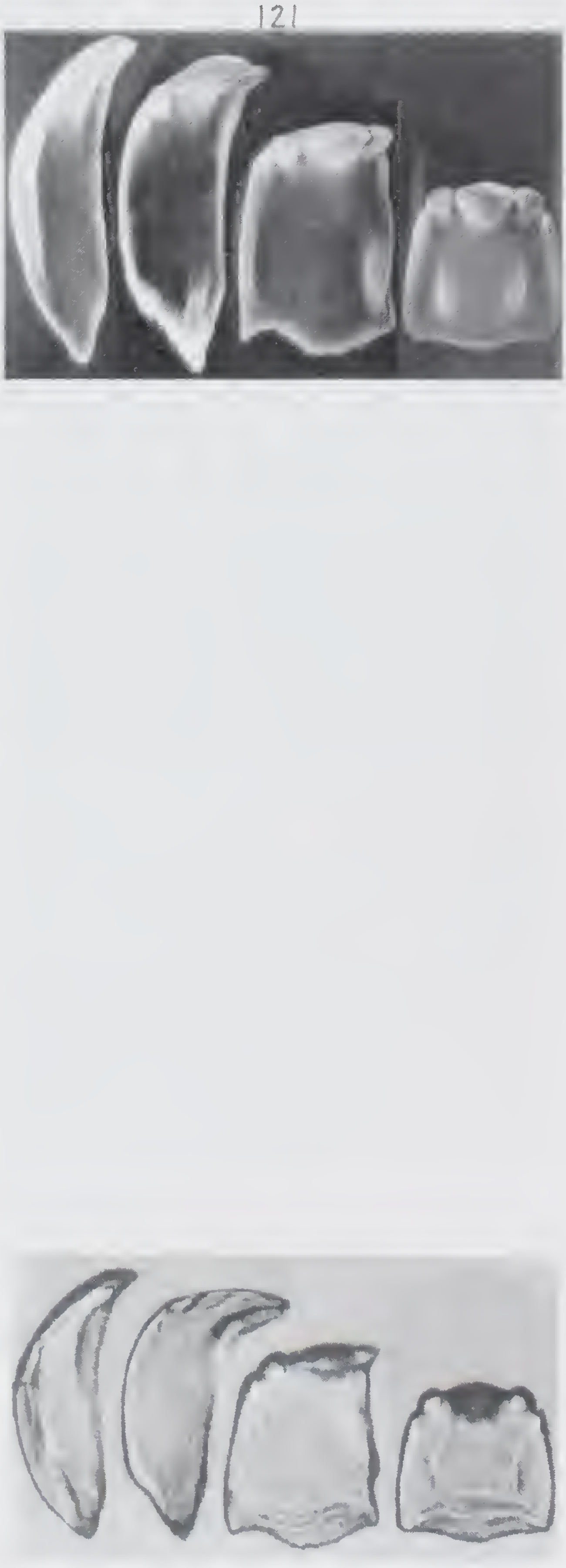


Figure 90. *Erronea lisetae*

153

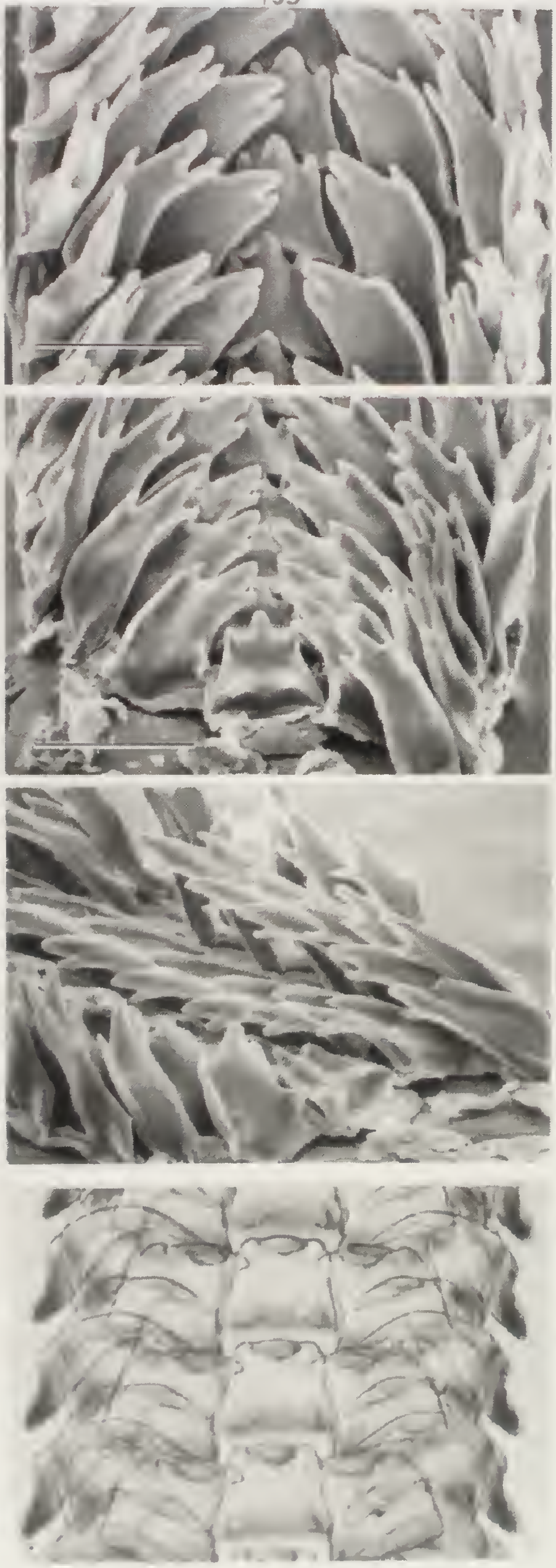


Figure 91. *Erronea onyx*

157

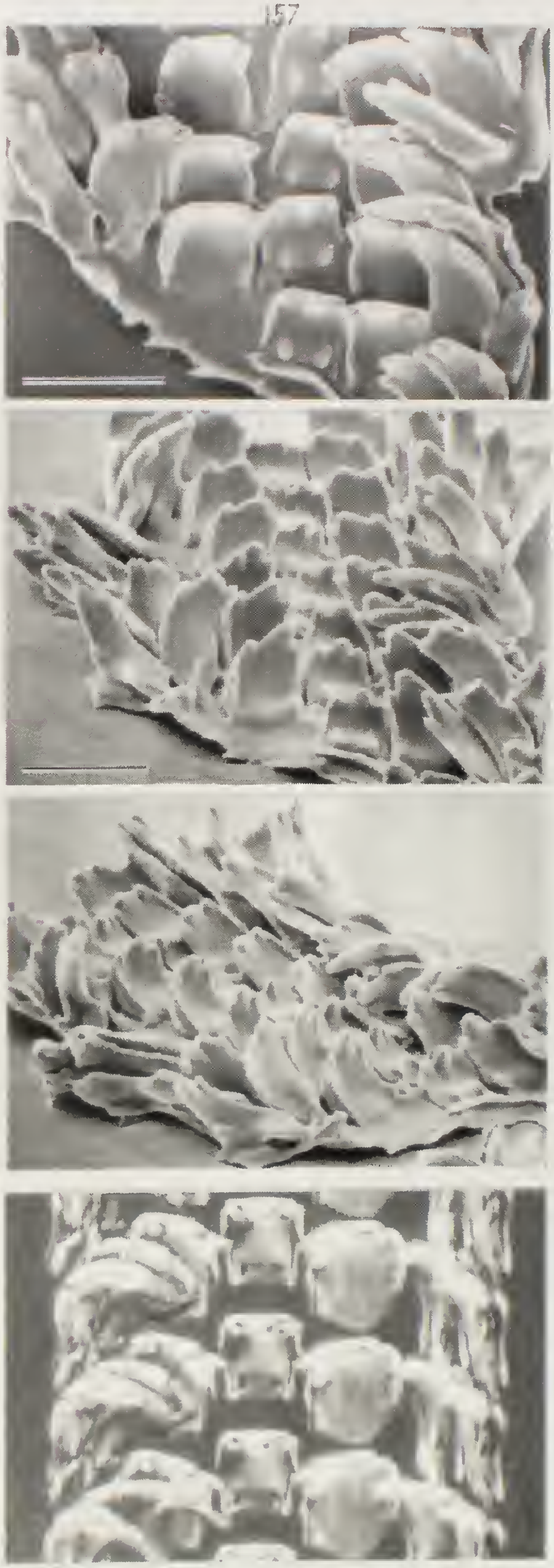


Figure 92. *Erronea pallida*

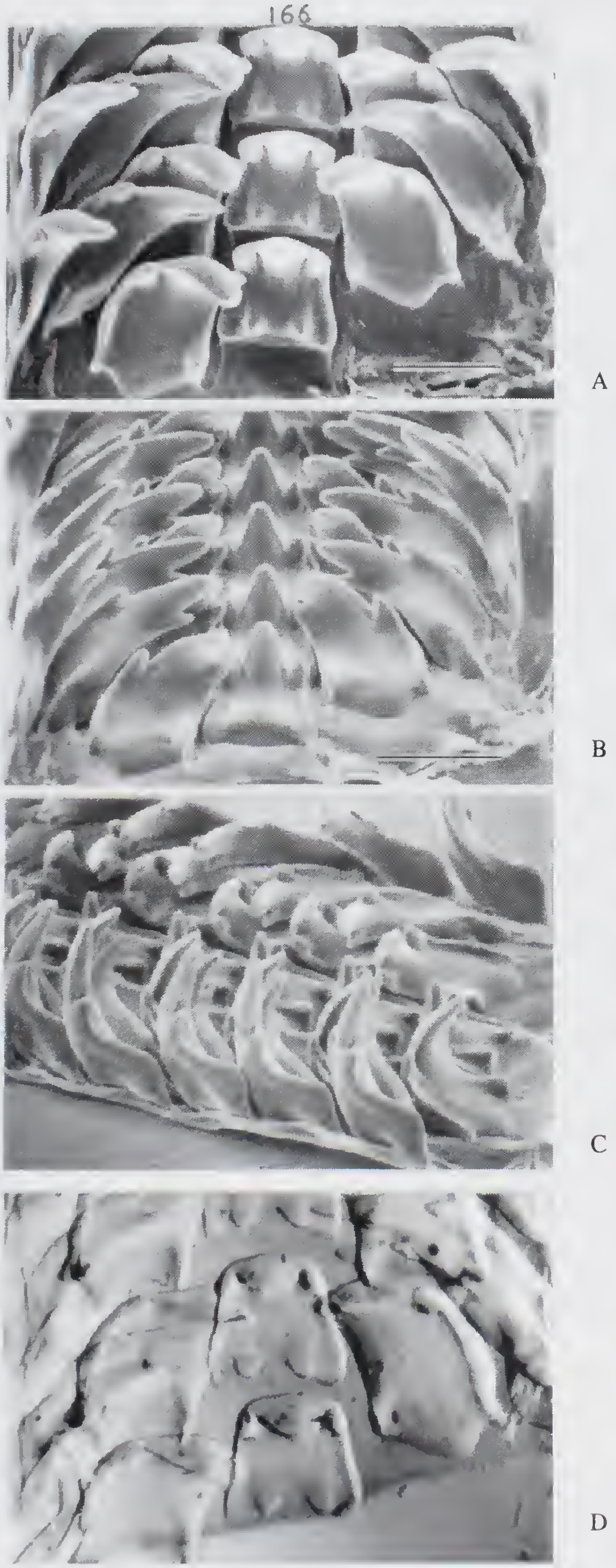


Figure 93. *Erronea pulchella*

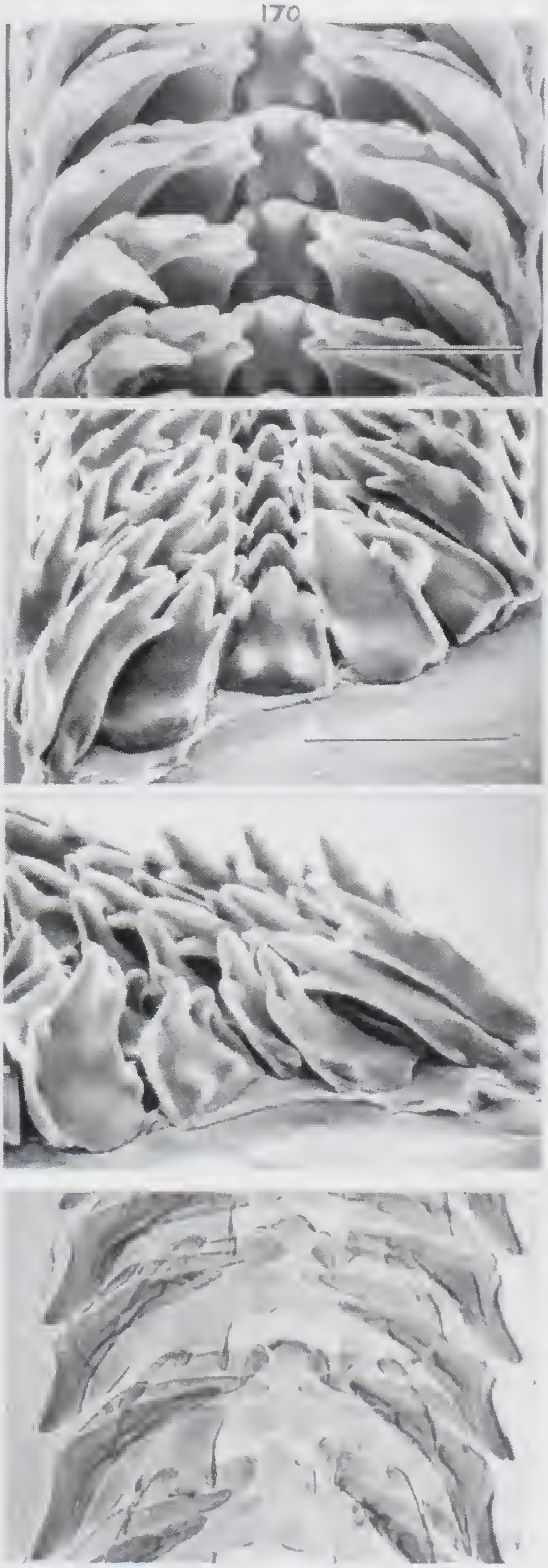


Figure 94. *Erronea pyriformis*

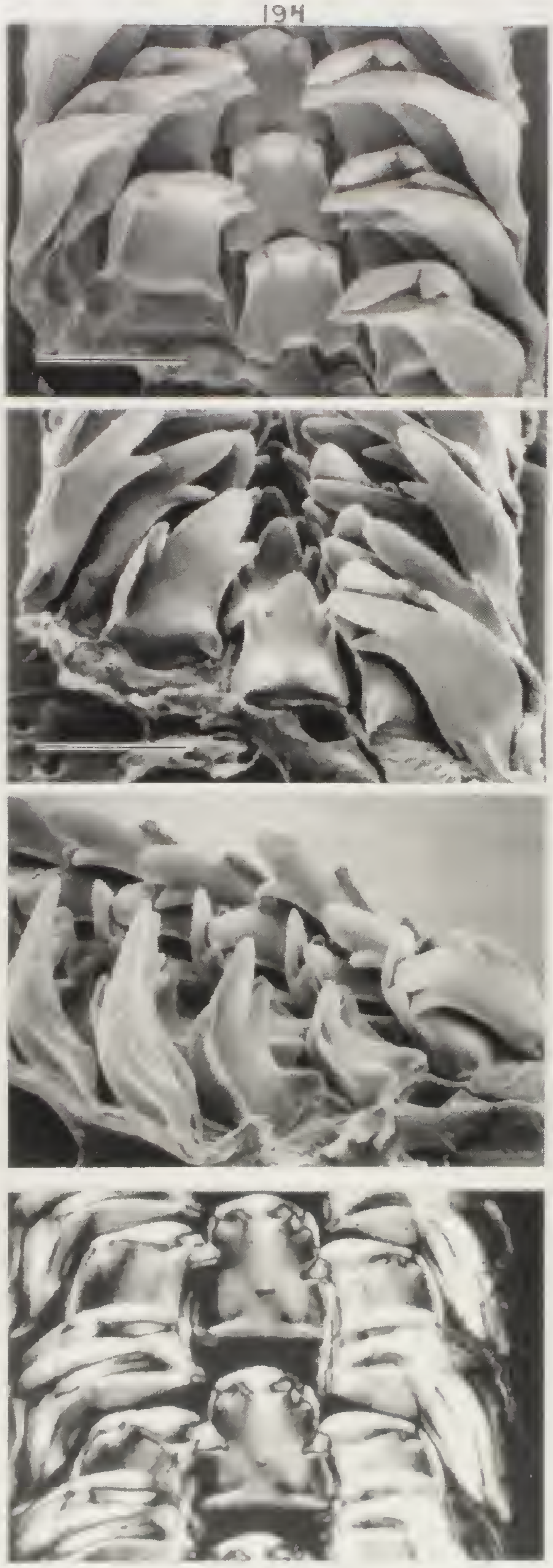


Figure 95. *Erronea subviridis*

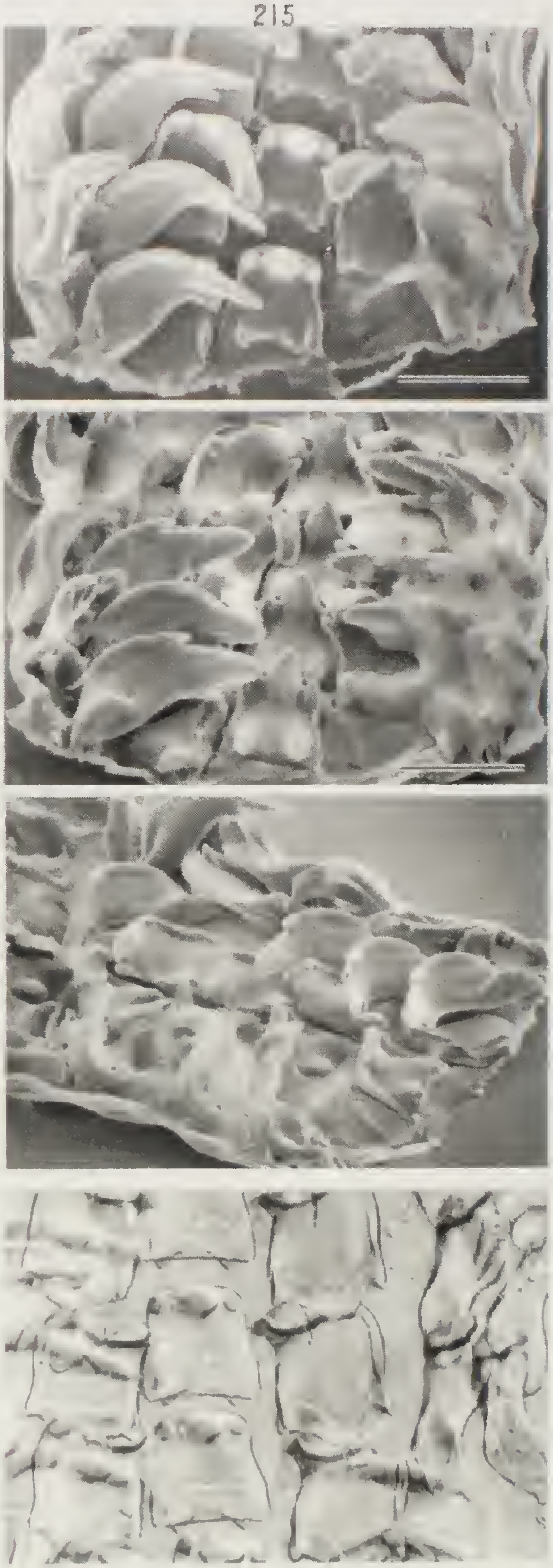


Figure 96. *Erronea vredenburgi*

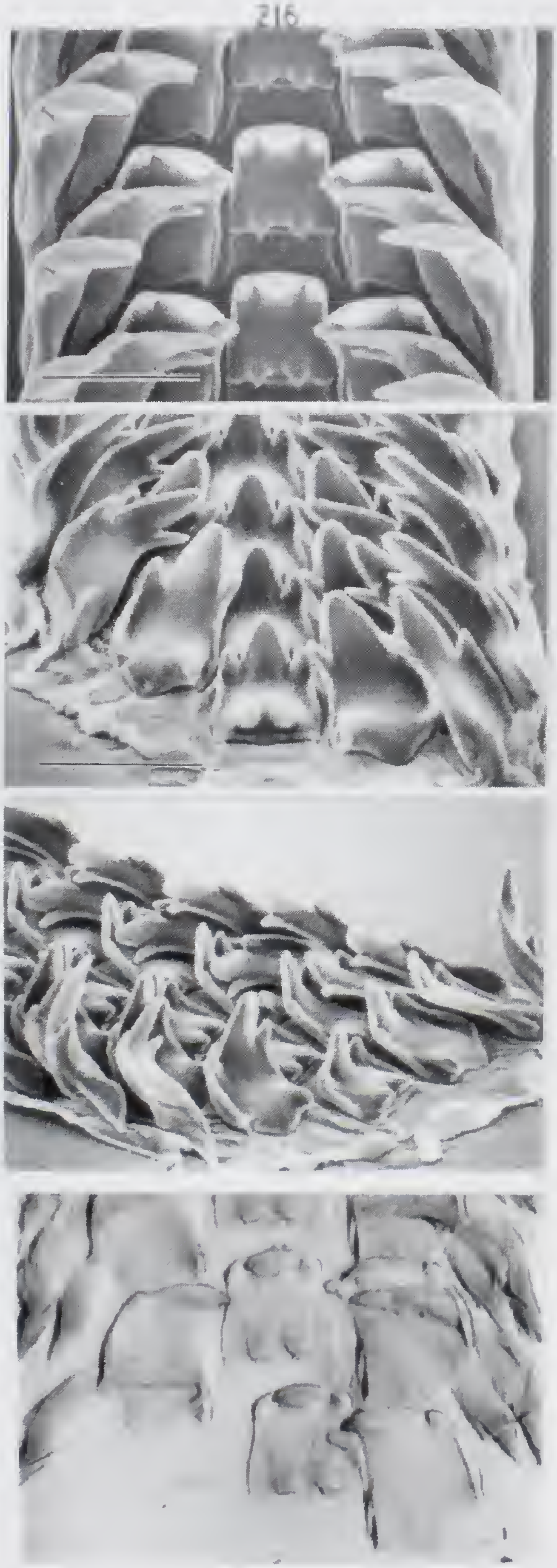


Figure 97. *Erronea walkeri*

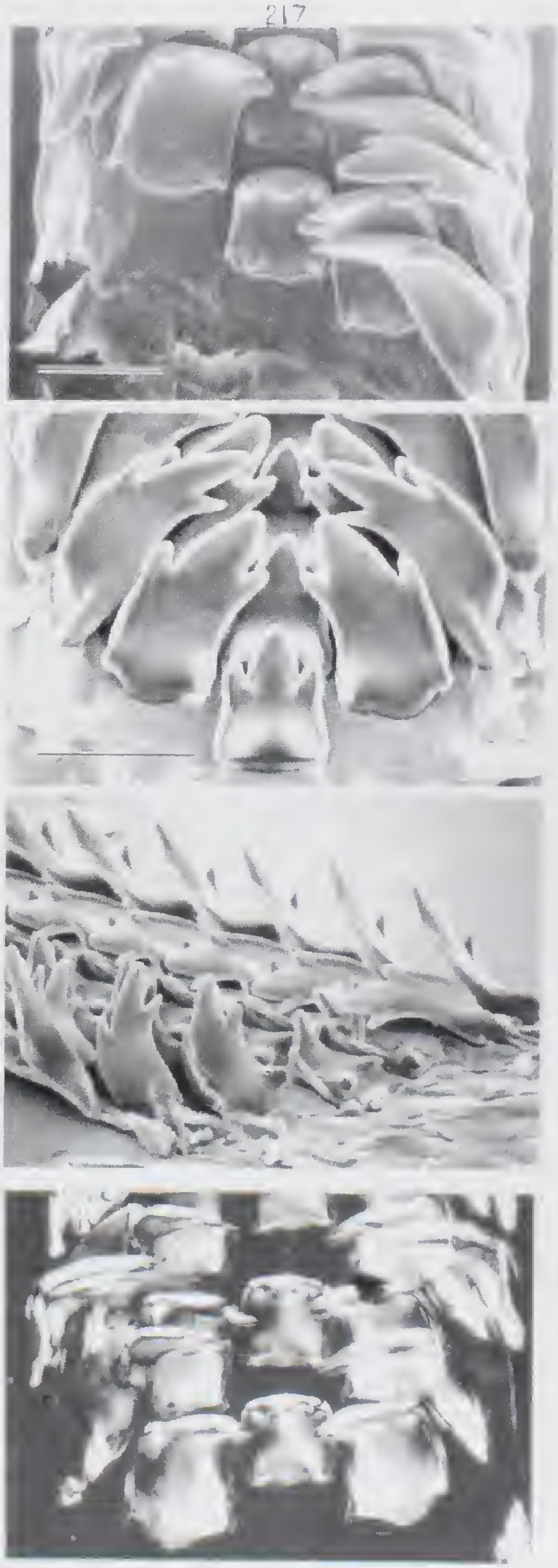


Figure 98. *Erronea xanthodon*

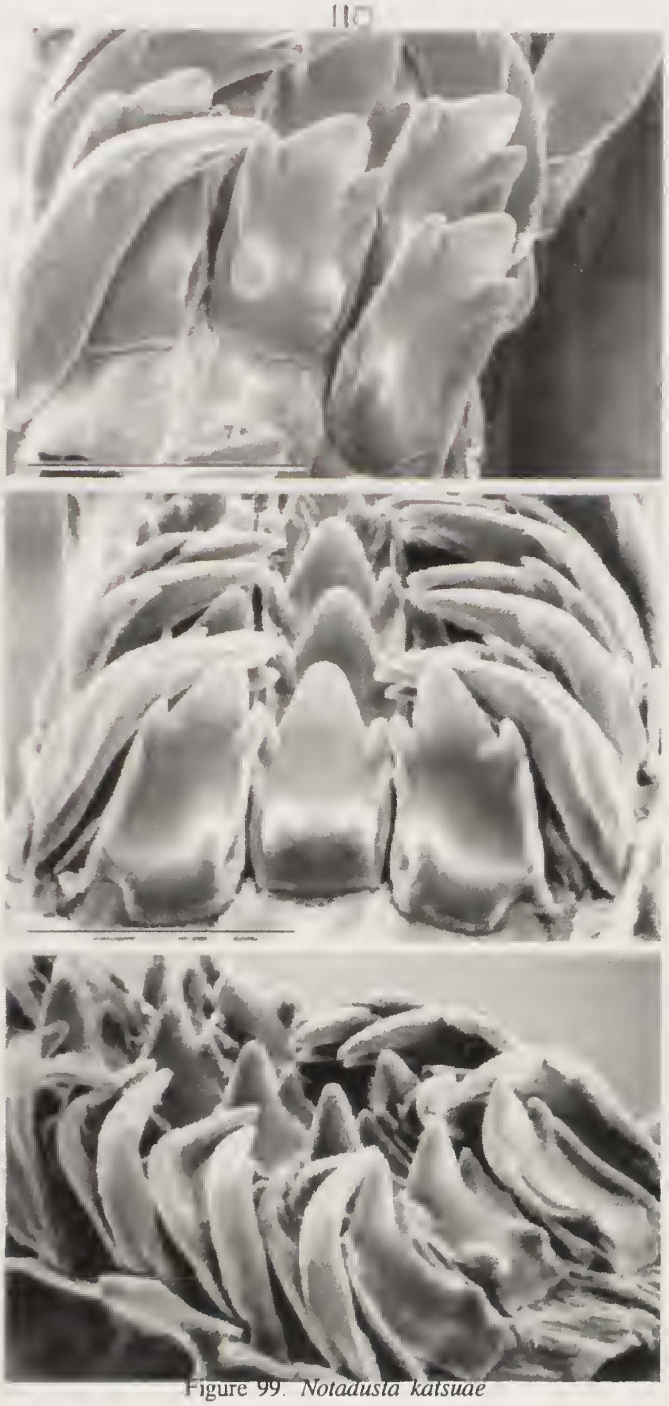


Figure 99. *Notadusta katsuae*

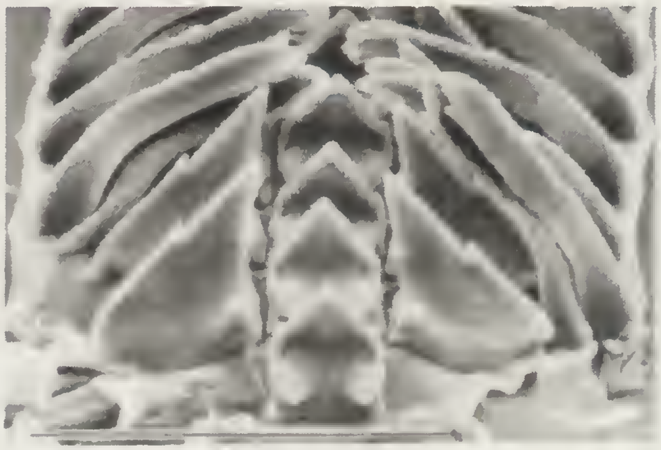


Figure 102. *Notadusta punctata*

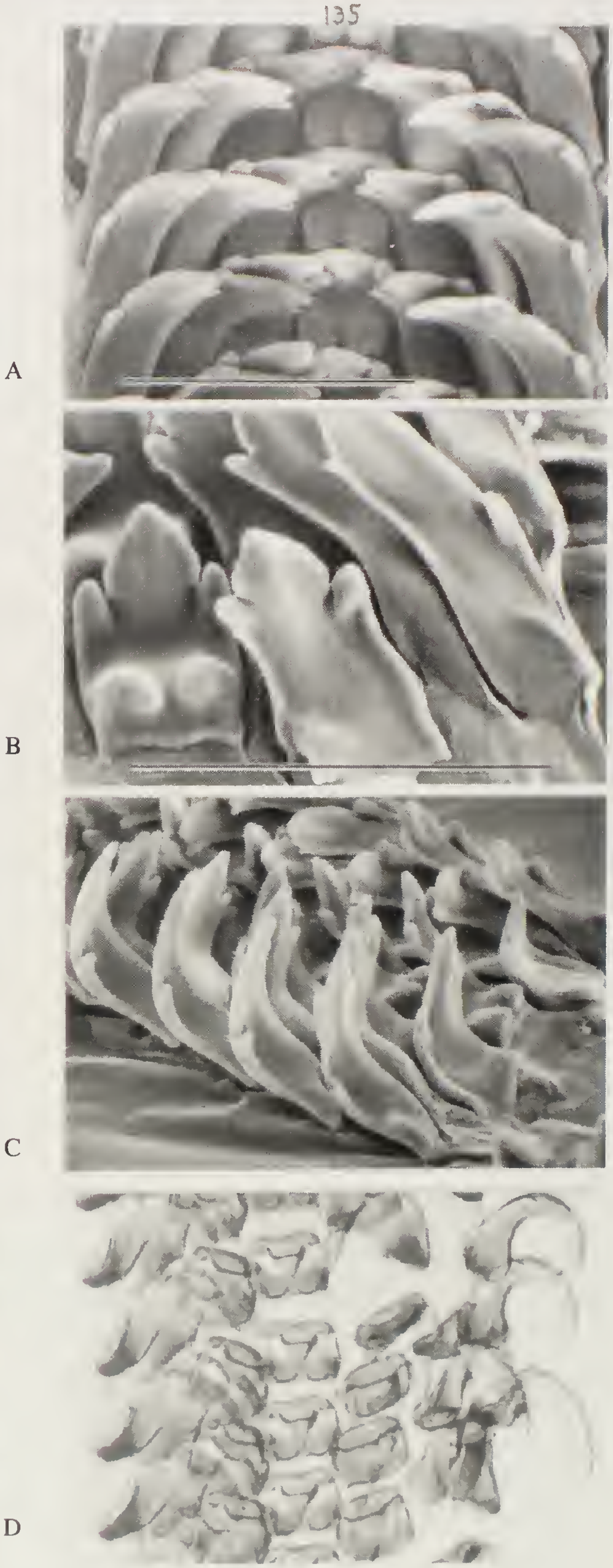


Figure 100. *Notadusta martini*

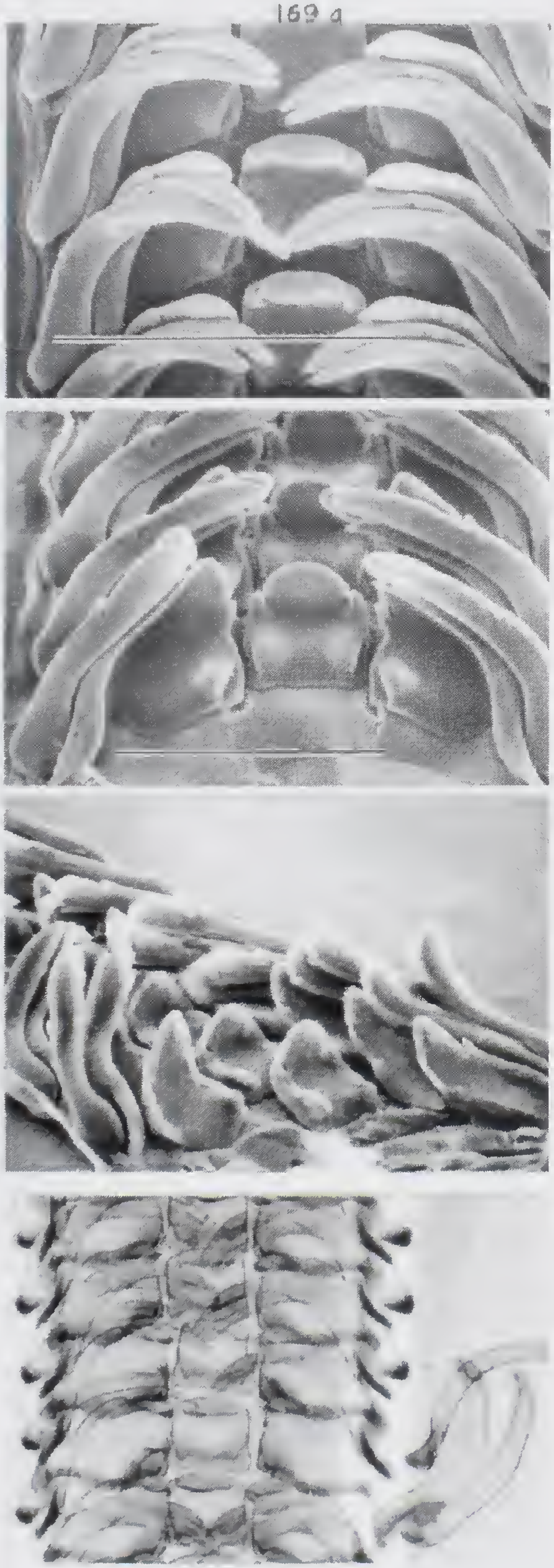


Figure 101. *Notadusta punctata*

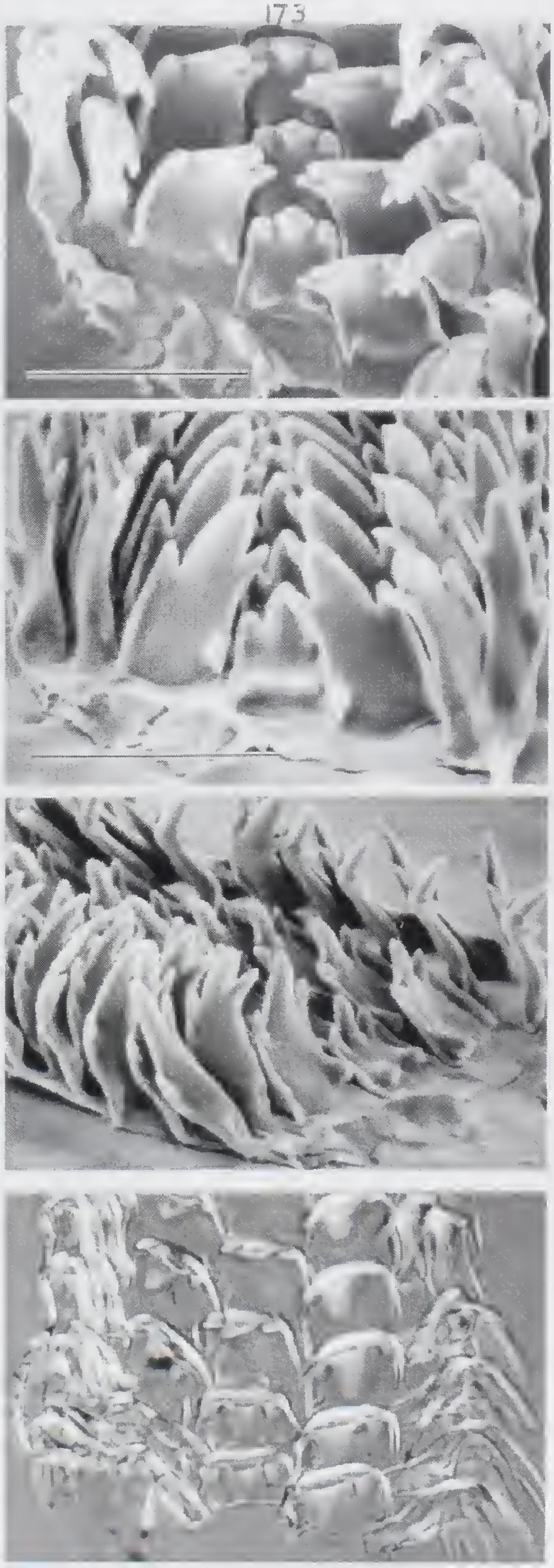
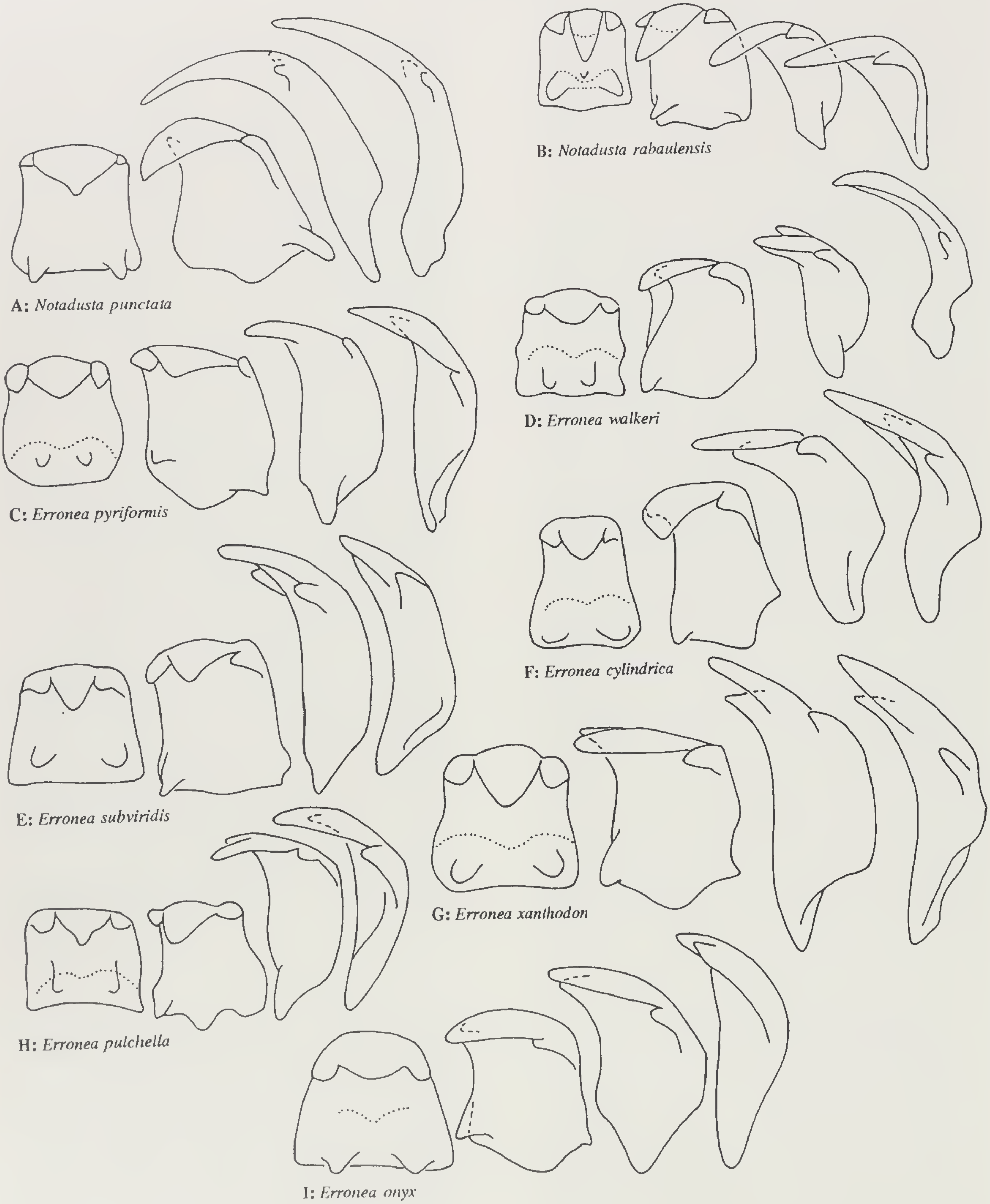


Figure 103. *Notadusta rabaulensis*



A: *Notadusta punctata*

B: *Notadusta rabaulensis*

C: *Erronea pyriformis*

D: *Erronea walkeri*

E: *Erronea subviridis*

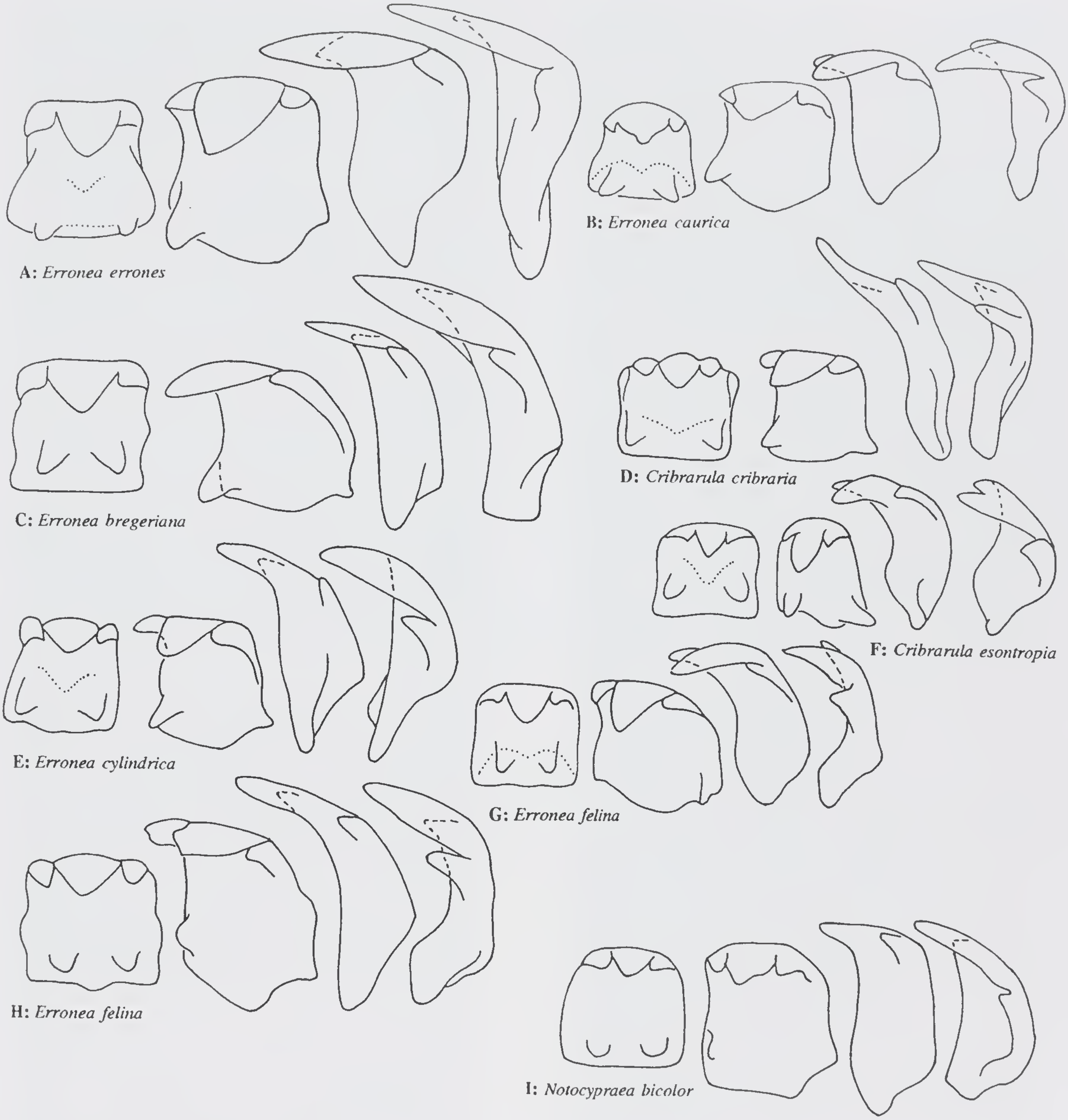
F: *Erronea cylindrica*

G: *Erronea xanthodon*

H: *Erronea pulchella*

I: *Erronea onyx*

Figure 104. Errones pattern drawings



A: *Erronea errones*

B: *Erronea caurica*

C: *Erronea bregeriana*

D: *Cribrarula cribraria*

E: *Erronea cylindrica*

F: *Cribrarula esontropia*

G: *Erronea felina*

H: *Erronea felina*

I: *Notocypraea bicolor*

Figure 105. Errones & Cicercula pattern drawings

The Mauritiana Pattern (Figures 106-131).

Model species: *Mauritia mauritiana* (Linnaeus, 1758).

Species: *Mauritia arabica* (Linnaeus; 1758), *M. arabicula* (Lamarck, 1810); *M. depressa* (Gray, 1824); *M. eglantina* (Duclos, 1833); *M. grayana* Schilder, 1930; *M. histrio* (Gmelin, 1791); *M. maculifera* Schilder; 1932, *M. mauritiana* (Linnaeus, 1758); *M. scurra* (Gmelin, 1791); *Macrocypraea cervinetta* (Kiener, 1843); M. cervus (Linnaeus, 1771); *M. zebra* (Linnaeus, 1758); *Trona stercoraria* (Linnaeus, 1758); *Zonaria aequinoctialis* Schilder, 1933; *Z. annettae* (Dall, 1909); *Z. gambiensis* (Shaw, 1909); *Z. petitiana* (Crosse, 1872); *Z. picta* (Gray, 1824); *Z. pyrum* (Gmelin, 1791); *Z. robertsi* (Hidalgo, 1906); *Z. sanguinolenta* (Gmelin, 1791); *Z. zonaria* (Gmelin, 1791); Z. *(Neobernaya) spadicea* (Swainson, 1823); Z. *(Pseudozonaria) nigropunctata* (Gray, 1828).

The central tooth in the mauritiana pattern, as in the tigris pattern, bears a pair of denticles that project below the basal platform, but the apex of the rectangular central tooth in the mauritiana pattern is straight rather than curved, and all the teeth on the radular ribbon are closely spaced and overlapping. The teeth are relatively large, in the 100 to 200 micron range (mean central tooth dimensions about 220x170 microns; n=45); except for the internal bract, they are not dark-staining. The central tooth is tricuspid, longer than wide (mean length/width ratio 1.4; n=45). The tricuspid laterals are larger than the central tooth, and project above the apex of the central tooth. The marginals are bladelike in profile, the inner marginal wider than the outer marginal, the bases narrow and independently attached to the radular membrane.

In *Mauritia maculifera* the base of each outer marginal articulates with the shaft of the marginal tooth below it. Bandel (1984) noted that in *M. arabica* the marginal teeth fit into each other; and together with their apices, lie in the concavity of the lateral teeth; concavities on the shaft of the marginal teeth are also seen in *M. depressa* (Figure 65) and *Trona stercoraria* (Figure 191). In *Macrocypraea zebra*, the cutting edge of the inner marginal projects inward, and the outer marginal rests with the apical part only on the outer margin of the inner marginal tooth (Bandel, 1984).

Central tooth dimensions: 170x120 to 410x245 microns (n=4) in *Macrocypraea*; 110x100 to 345x175 microns (n=18) in *Mauritia*; 80x85 to 225x175 microns (n=18) in *Zonaria*. No. of radular rows: 95 to 180 (n=6) in *Macrocypraea;* 75 to 200 (n=6) in *Mauritia*; 180 to 230 (n=2) in *Trona*; 77 to 160 (n=11) in *Zonaria*. No. of radular rows per mm radula: 3.3 to 4.7 (n=14) in *Macrocypraea;* 3.8 to 6.6 (n=12) in *Mauritia*; 3.8 to 4.2 (n=2) in *Trona*; 3.3 to 10.7 (n=19) in *Zonaria*. Cowries with the mauritiana radular pattern are found virtually around the world: *Mauritia* is perhaps best known in the Indo-West Pacific, but one species, along with *Macrocypraea* and *Zonaria*, is found on the west coast of the Americas; species of *Macrocypraea* also occur in the Caribbean; and *Zonaria* and *Trona* are found on the west coast of Africa and in the Mediterranean. The genus *Mauritia* was described by Troschel (1863), who characterized the cusp of the central tooth as truncated. The shells are massive, among the largest of the cowries. The fossula is broad and ridged in *Mauritia*, spoon-like with complex ribbing in *Macrocypraea* and *Trona*, and shallow and indistinctly ribbed in *Zonaria*. The mantles are brown or mottled gray and brown, the papillae lighter in color and branched. The females in all four genera lack a bursa copulatrix. Development is by planktonic veliger larvae in *Mauritia* although large, bulbous larval shells suggest a short planktonic life; juvenile cowries hatch from the egg capsules in the other genera. The earliest fossils of *Mauritia* and *Macrocypraea* are known from the late Miocene of Indonesia and the Caribbean respectively; *Trona* is known from the Oligocene of Europe, and *Zonaria* from the Paleocene of Greenland.

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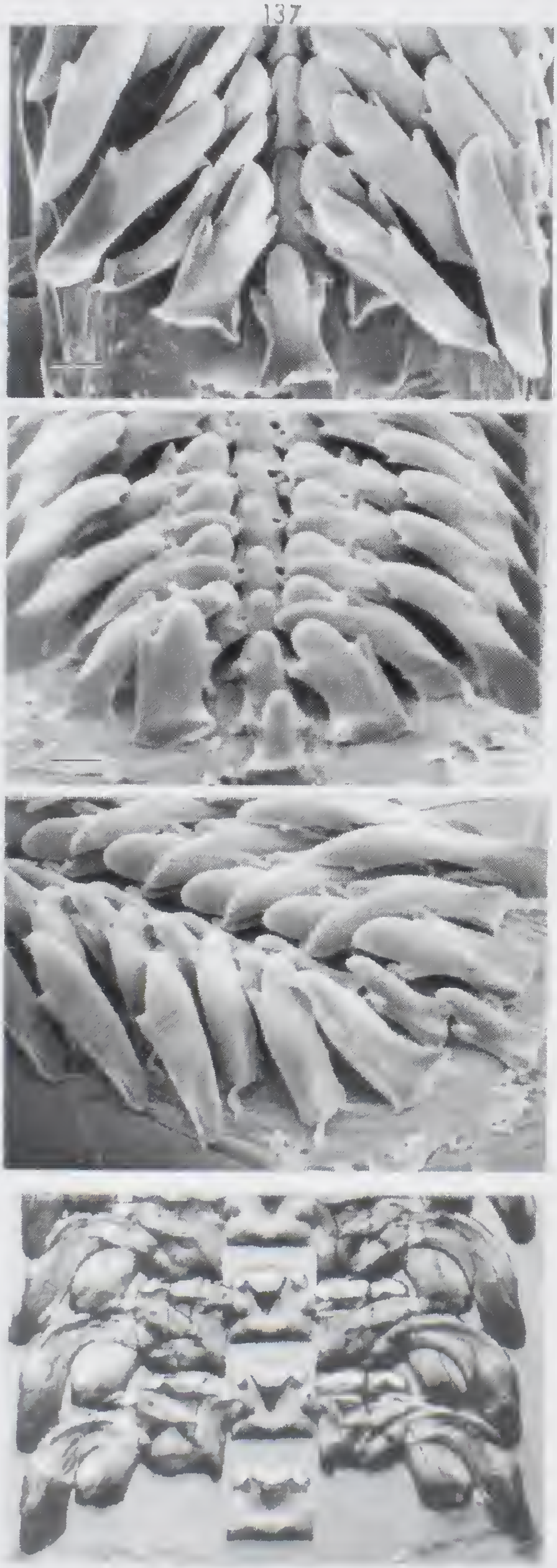

Figure 106. *Mauritia mauritiana*

12

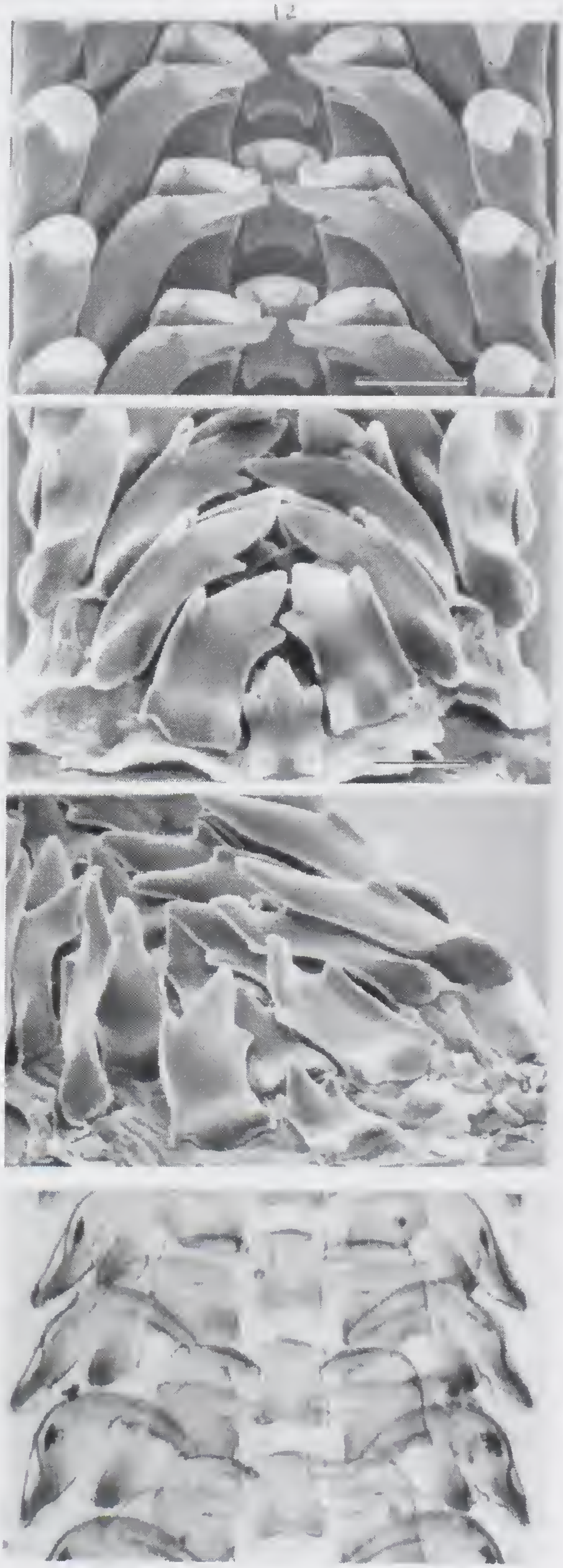

Figure 107. *Mauritia arabica*

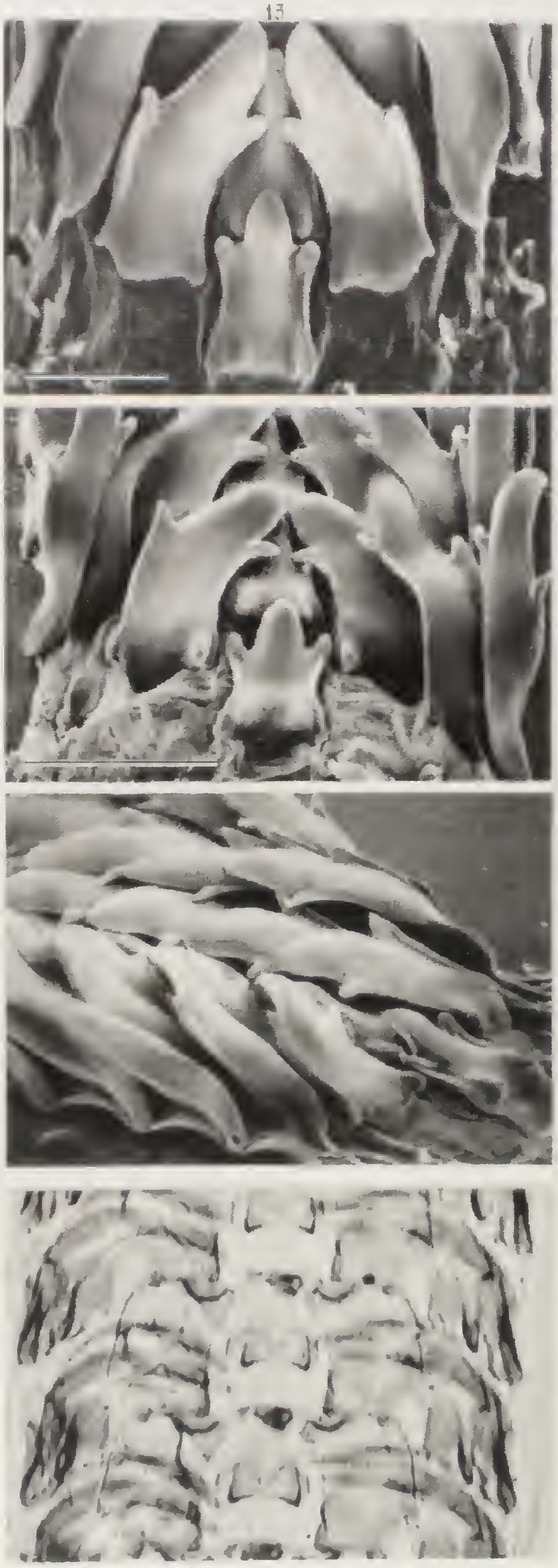

Figure 108. *Mauritia arabicula*

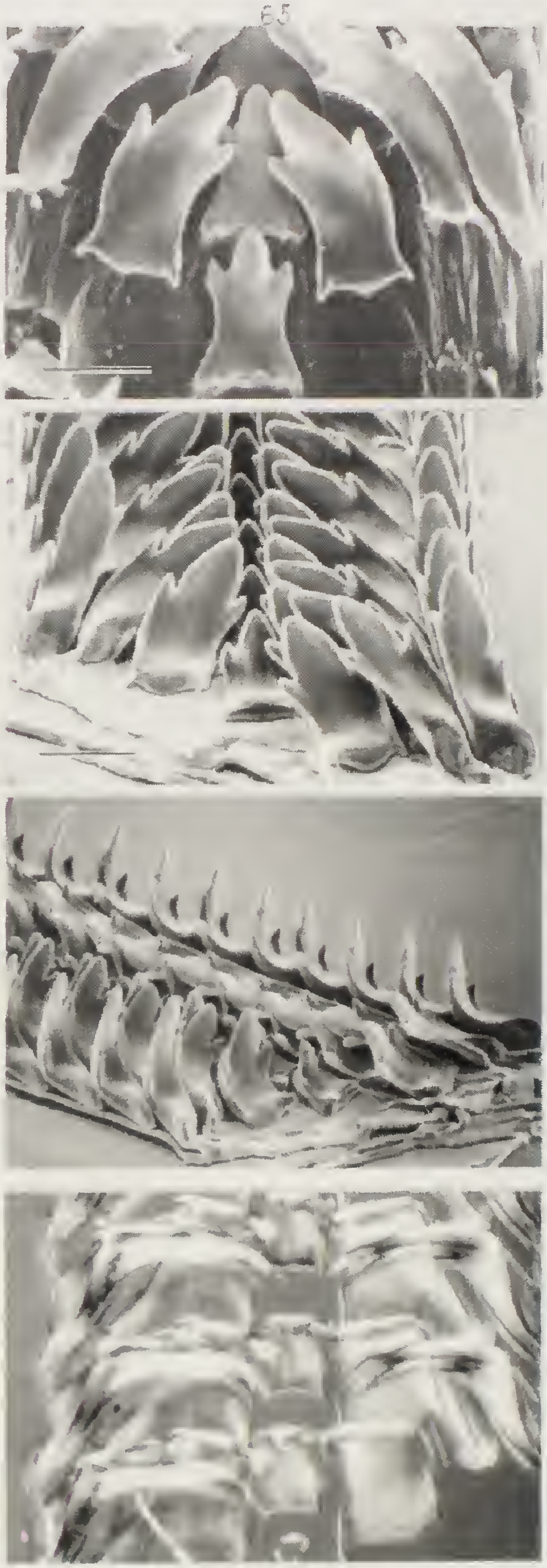

Figure 109. *Mauritia depressa*

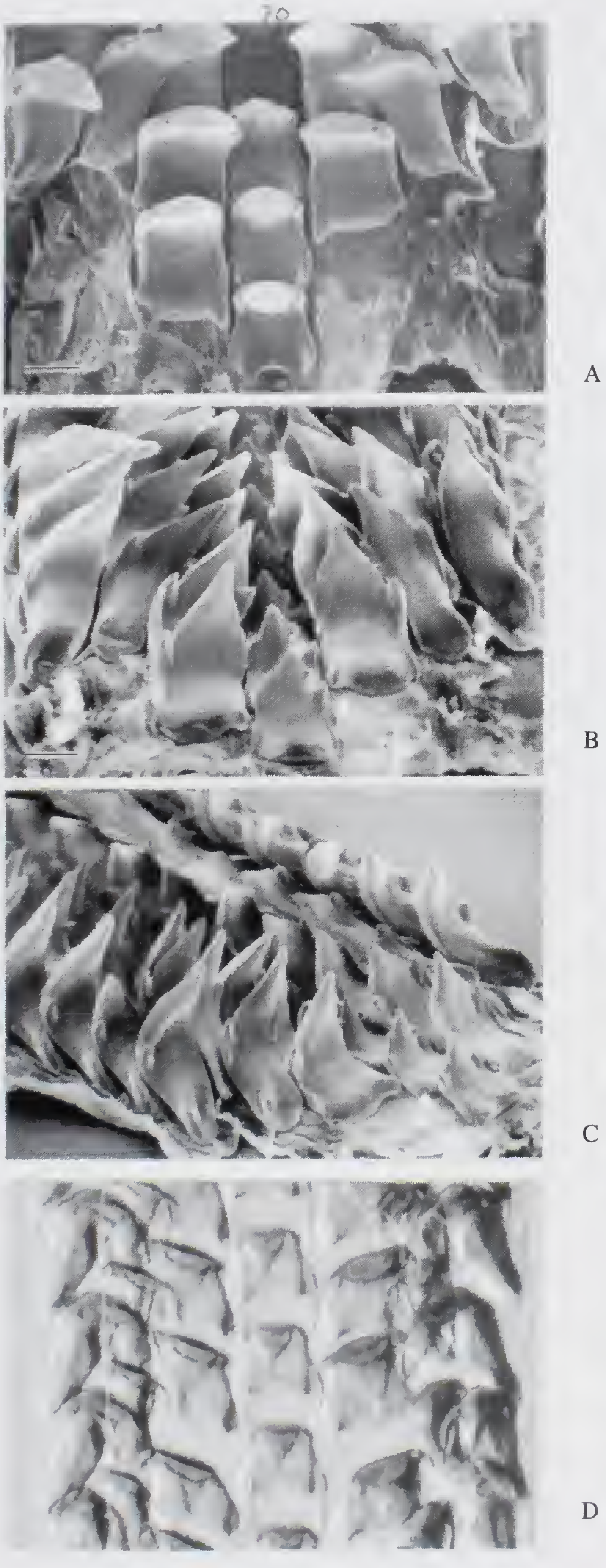

Figure 110. *Mauritia eglantina*

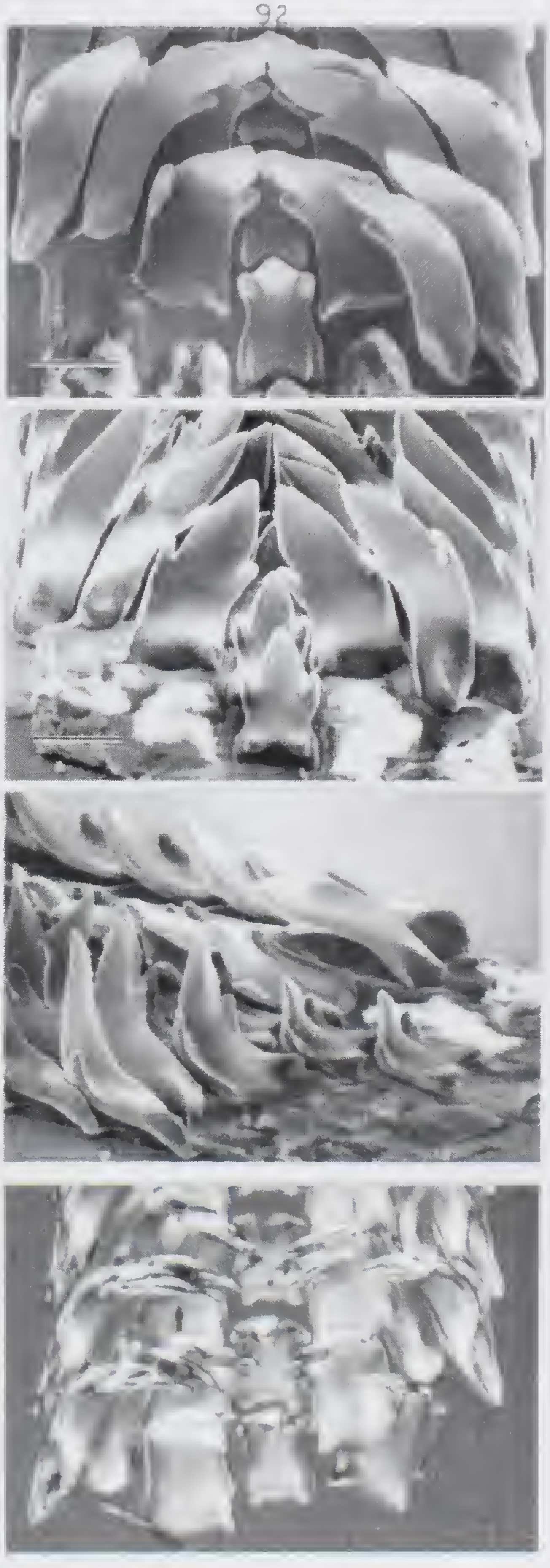

Figure 111. *Mauritia grayana*

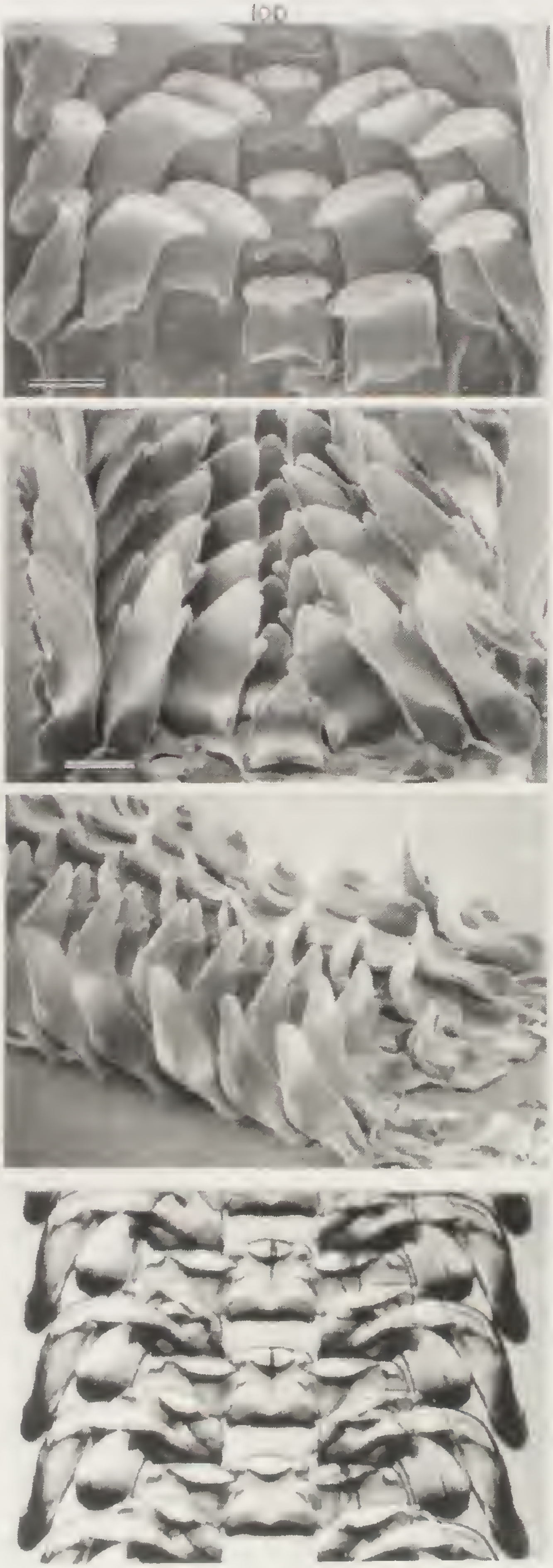

Figure 112. *Mauritia histrio*

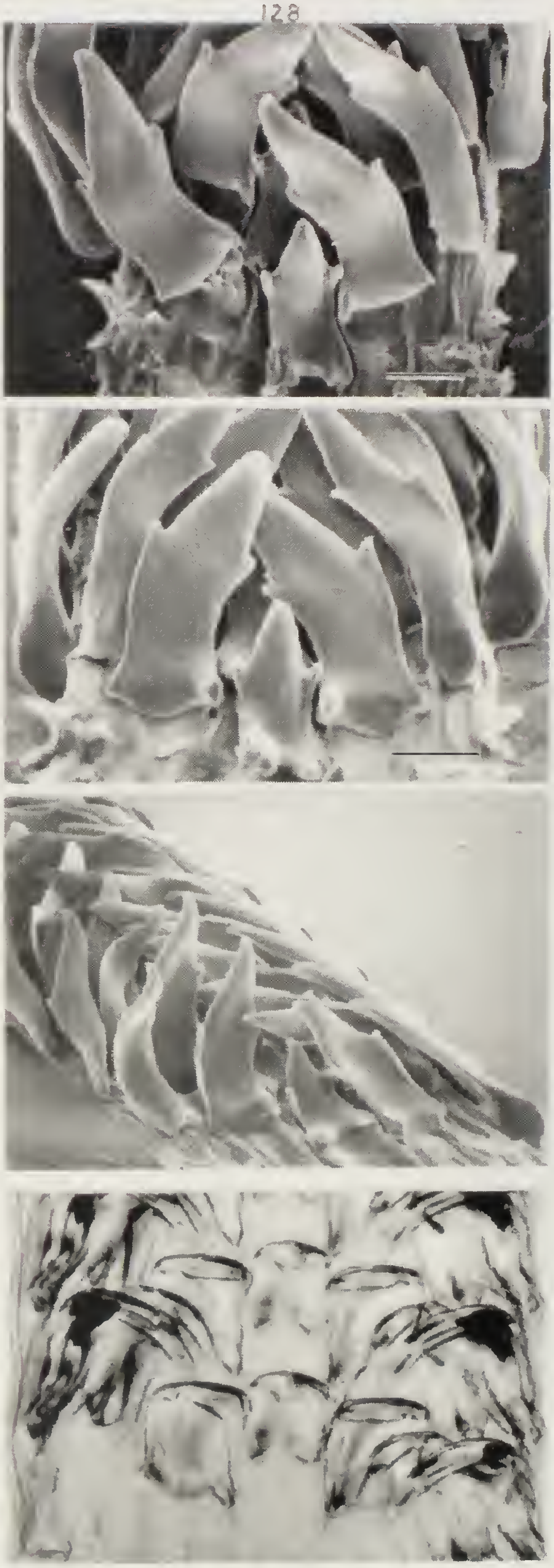

Figure 113. *Mauritia maculifera*

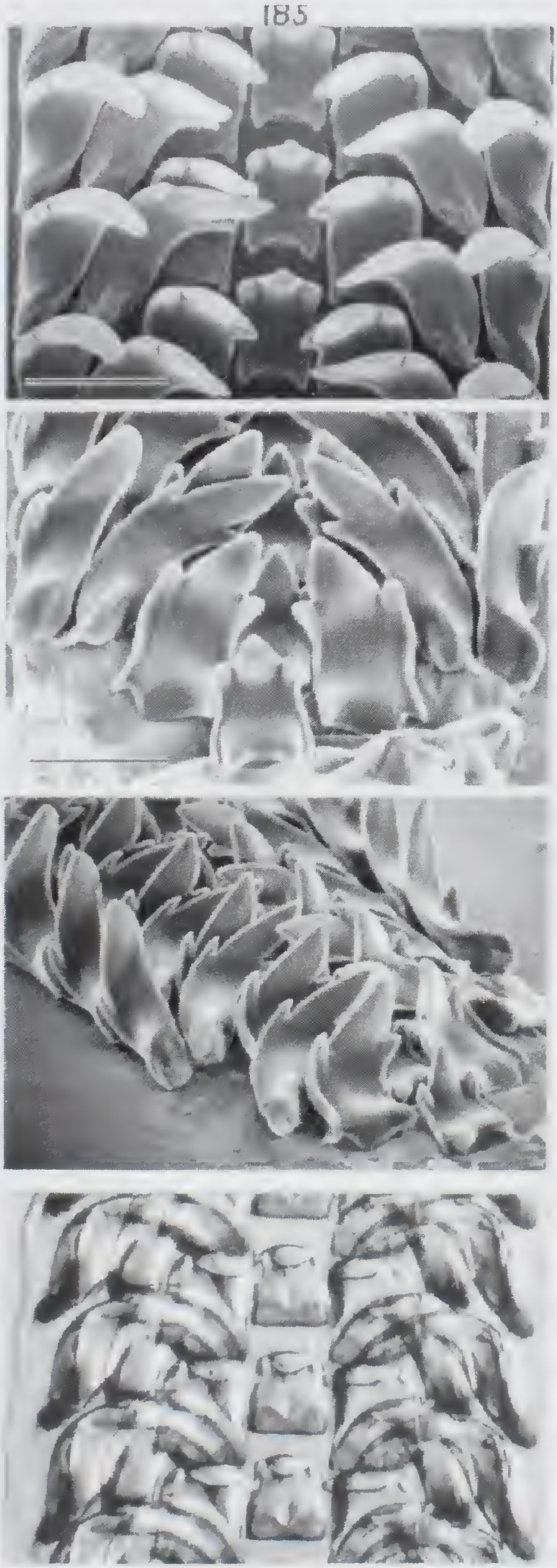

Figure 114. *Mauritia scurra*

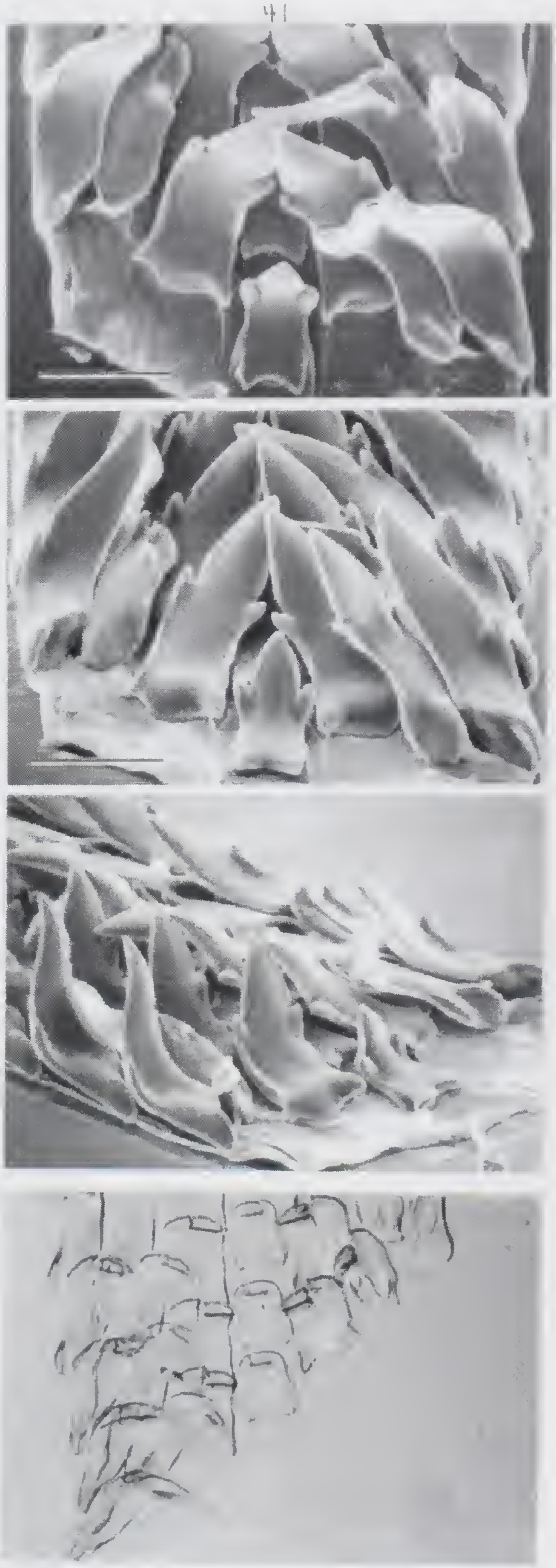

Figure 115. *Macrocypraea cervinetta*

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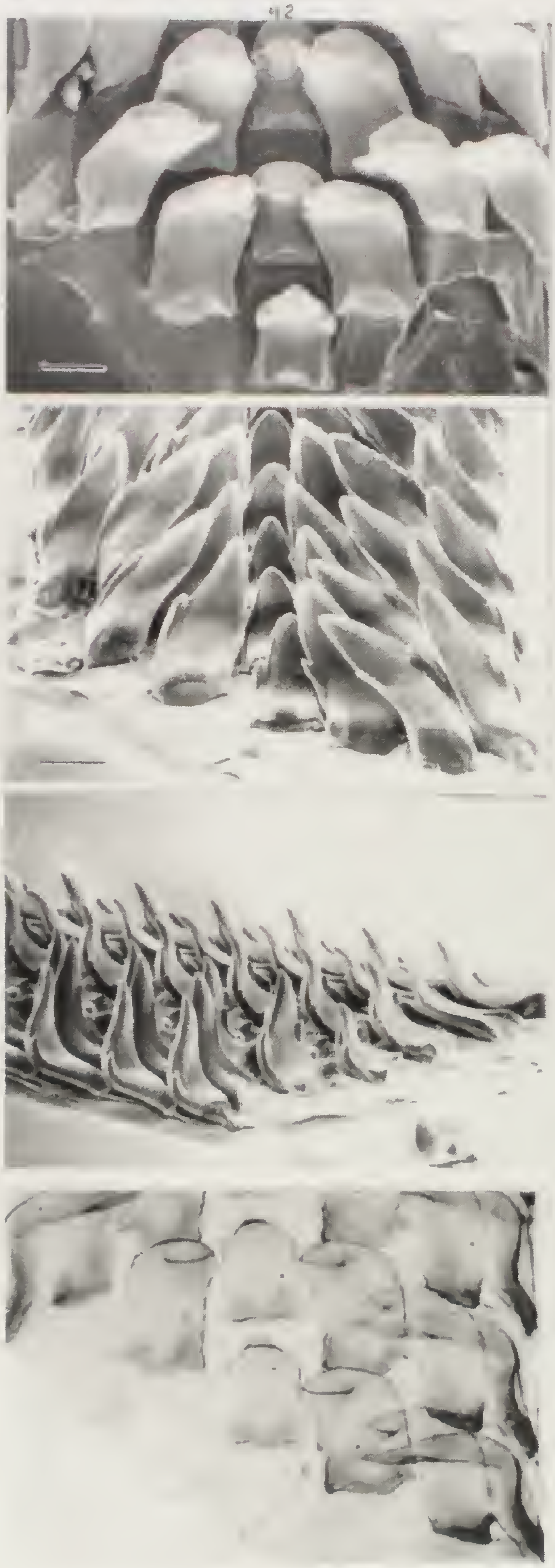


Figure 116. *Macrocypraea cervus*

219

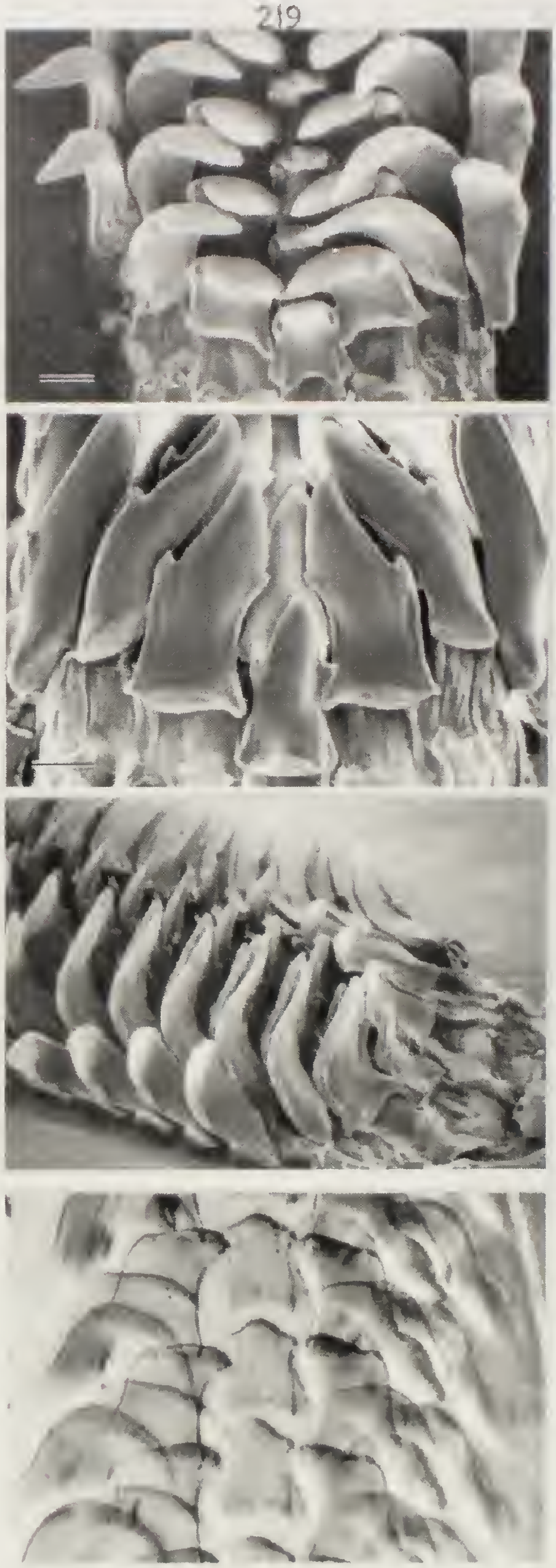


Figure 117. *Macrocypraea zebra*

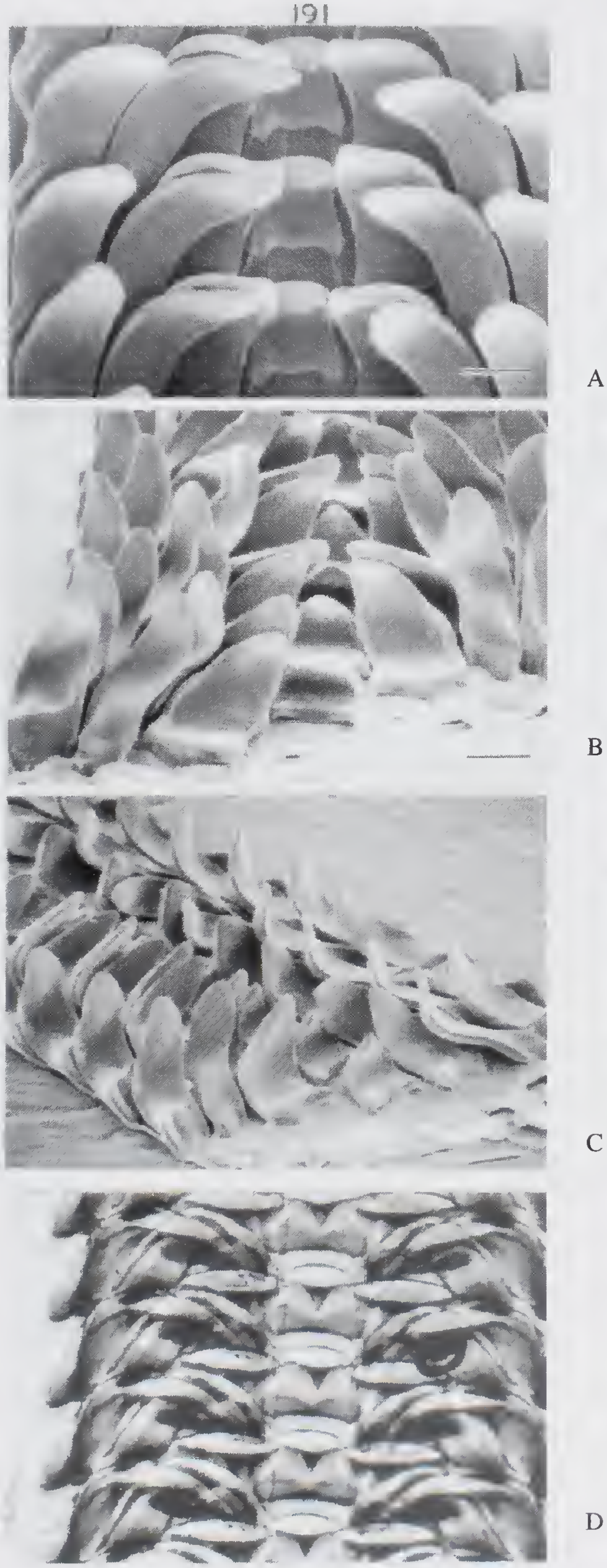


Figure 118. *Trona stercoraria*

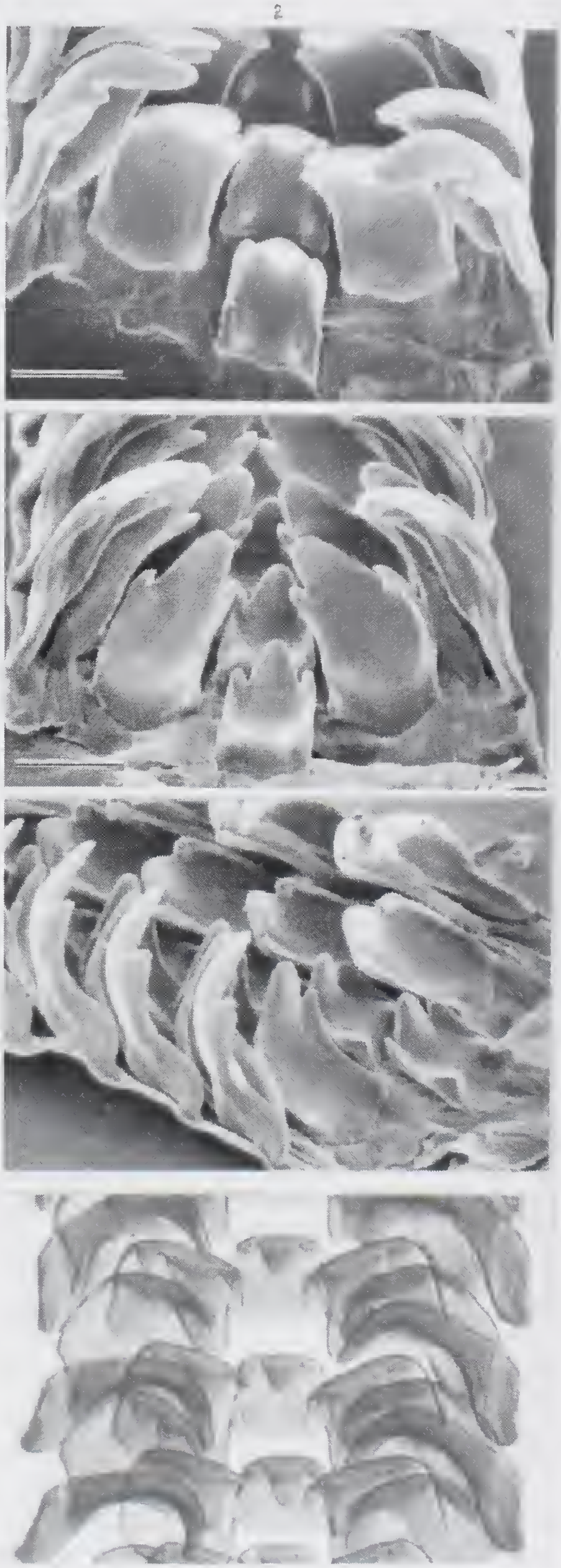


Figure 119. *Zonaria aequinoctialis*

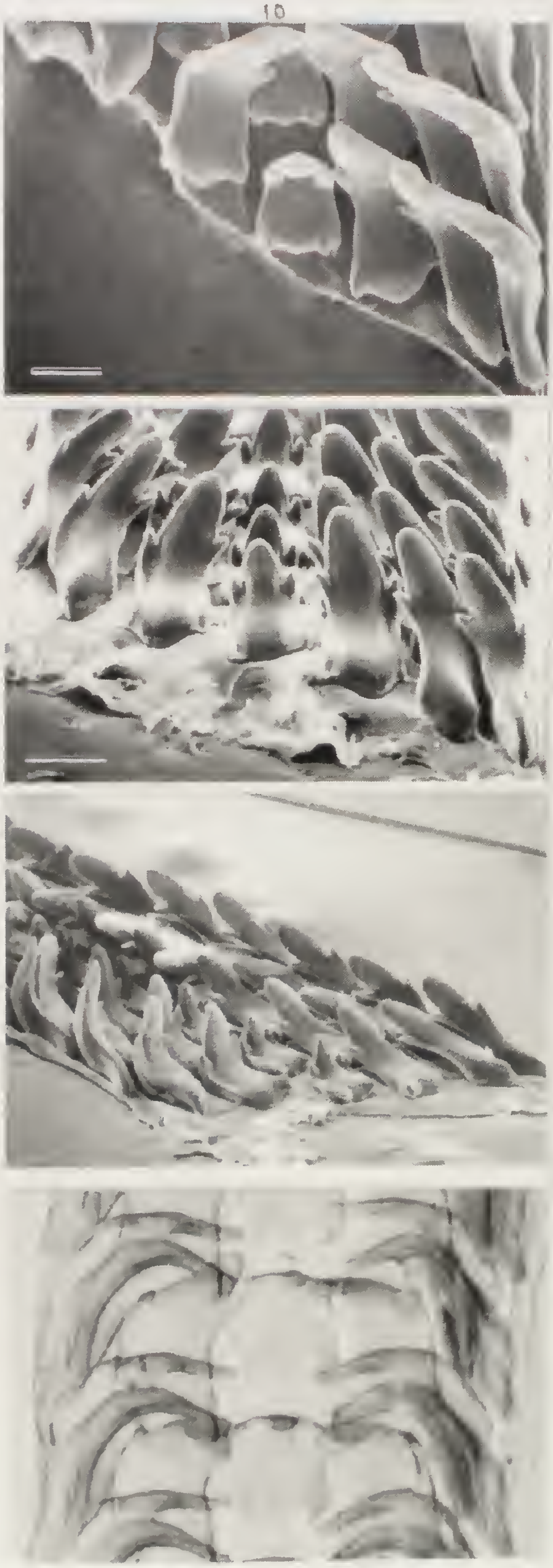


Figure 120. *Zonaria annettae*

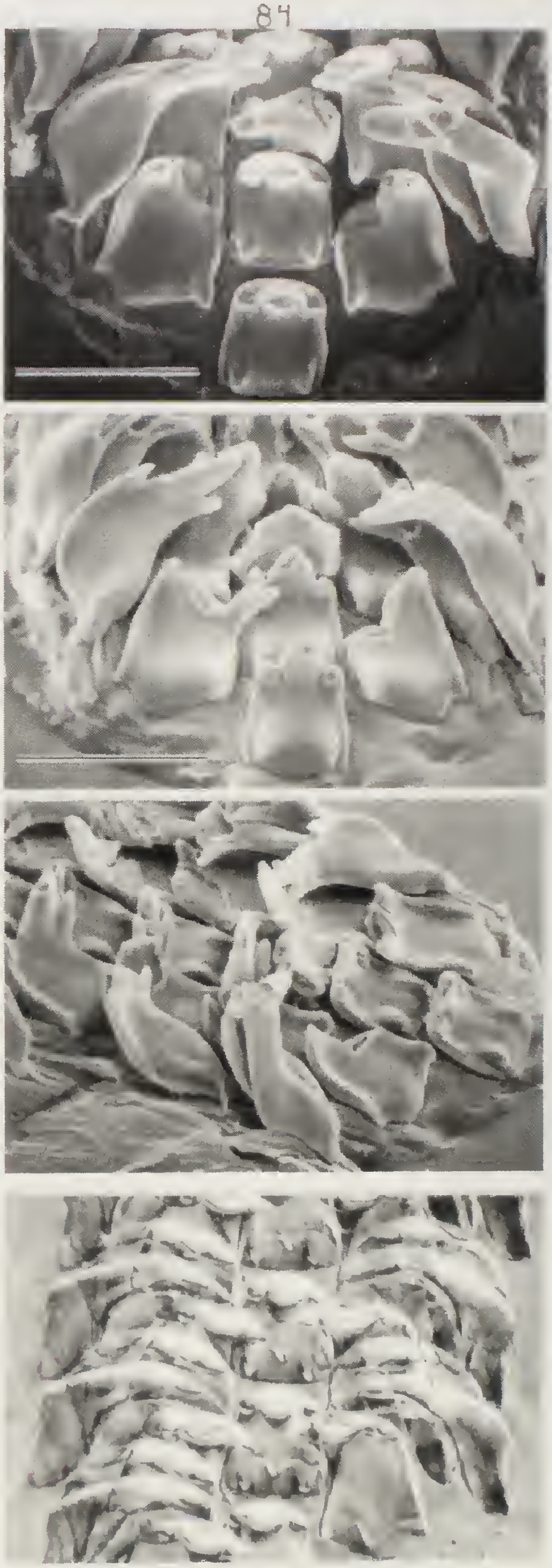


Figure 121. *Zonaria gambiensis*

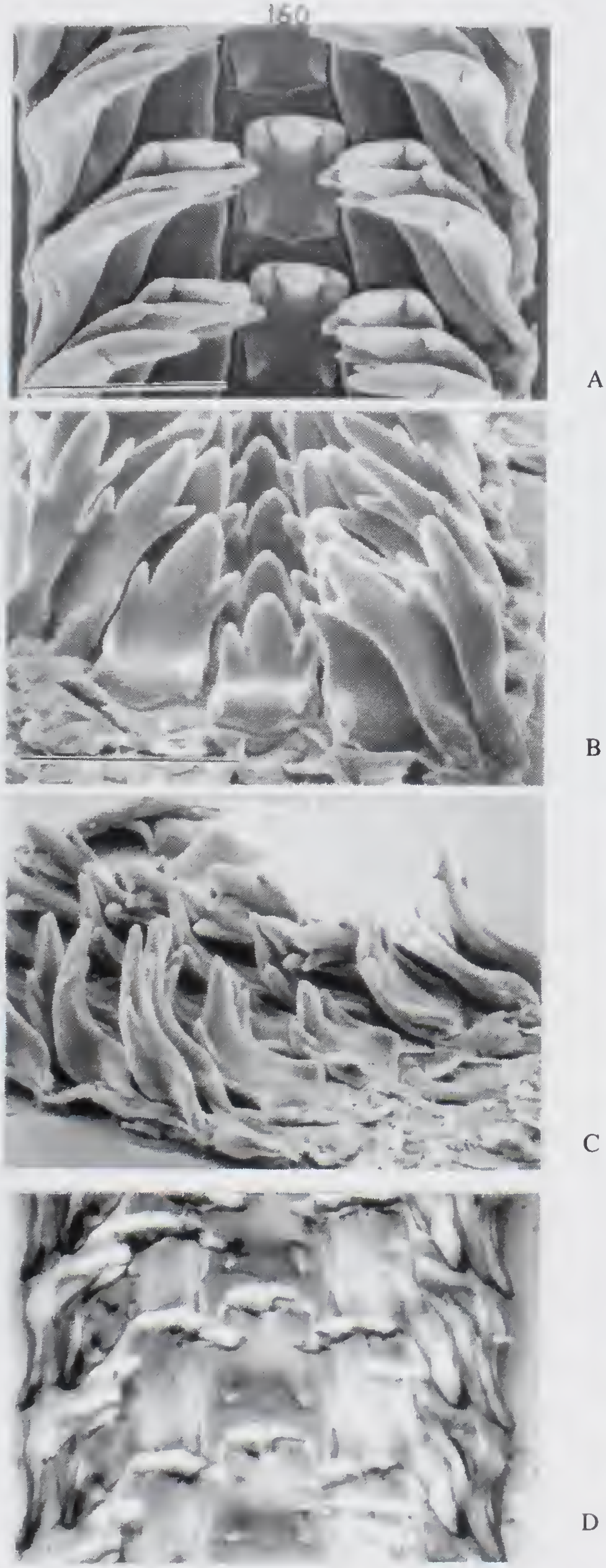


Figure 122. *Zonaria petitiana*

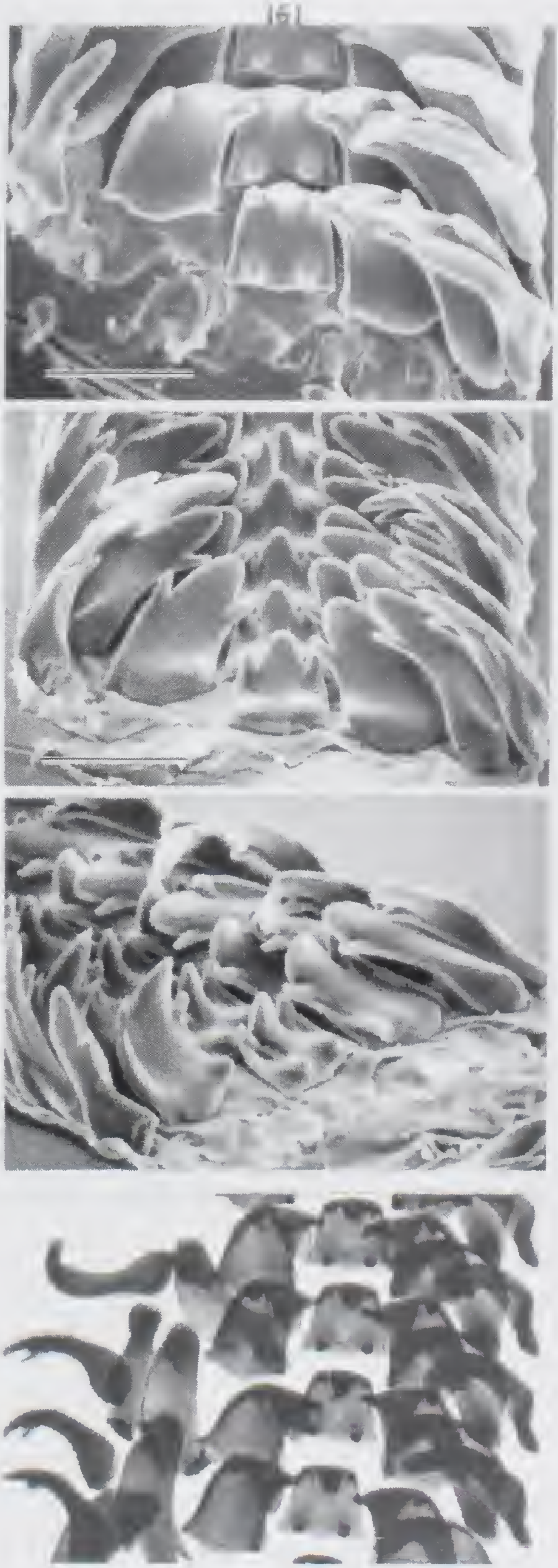


Figure 123. *Zonaria picta*

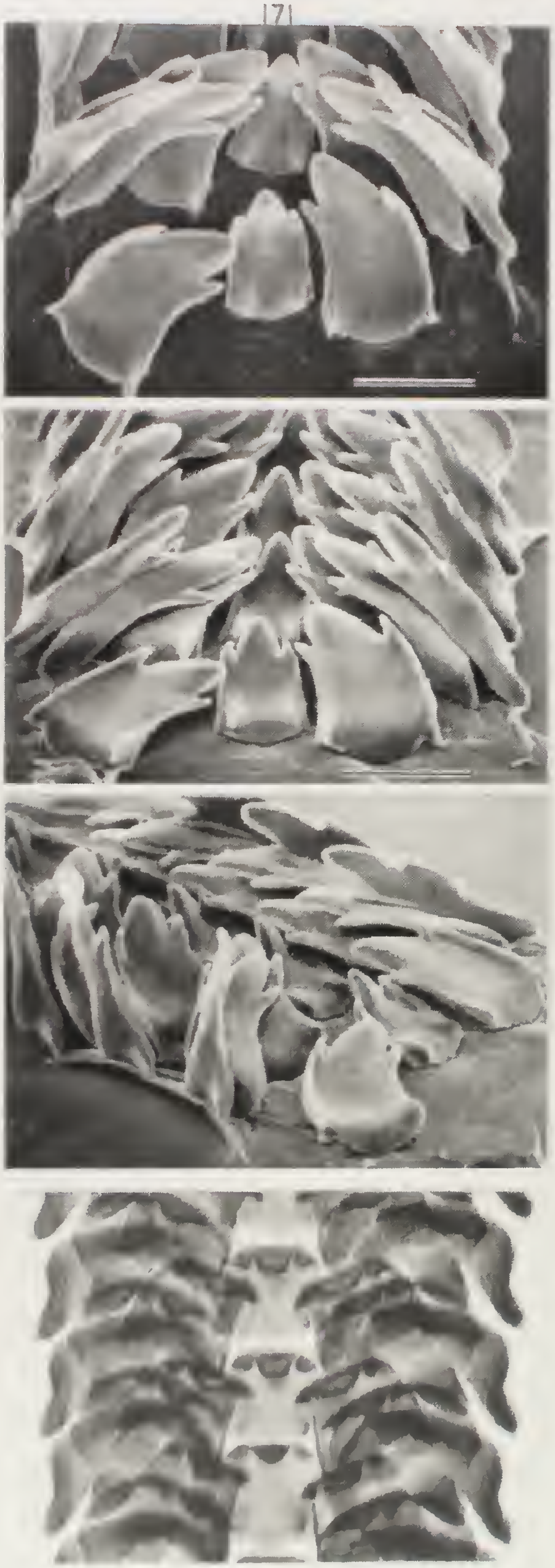


Figure 124. *Zonaria pyrum*

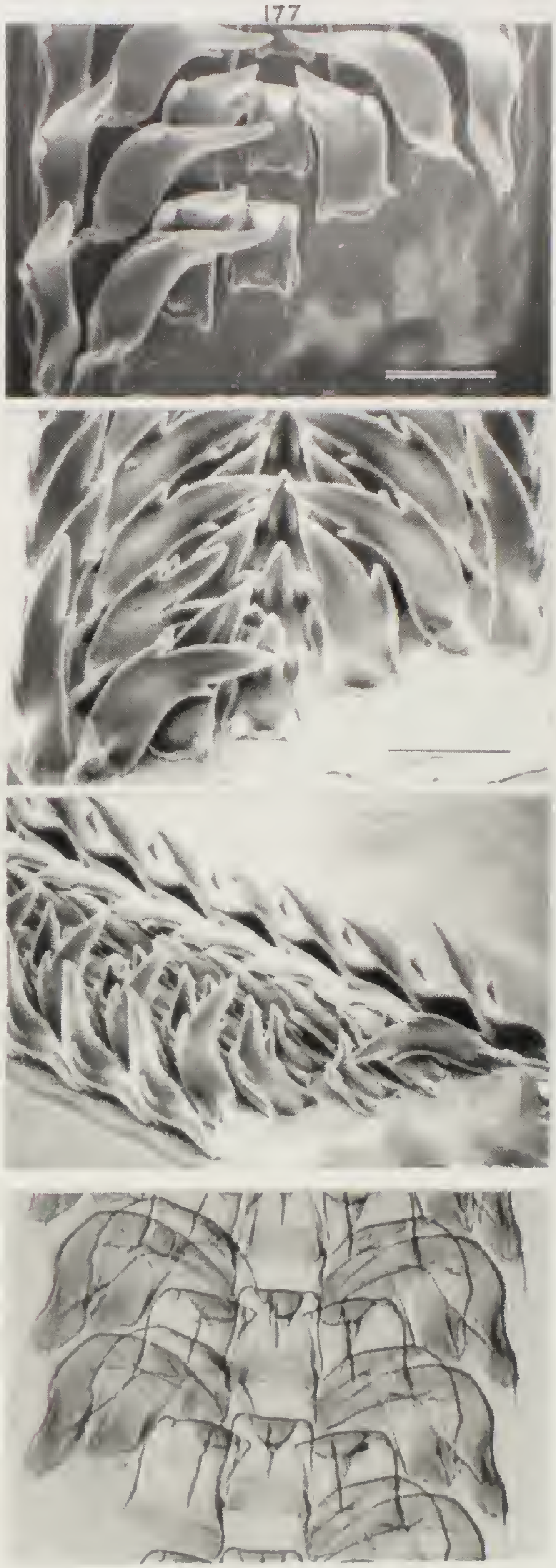


Figure 125. *Zonaria robertsi*

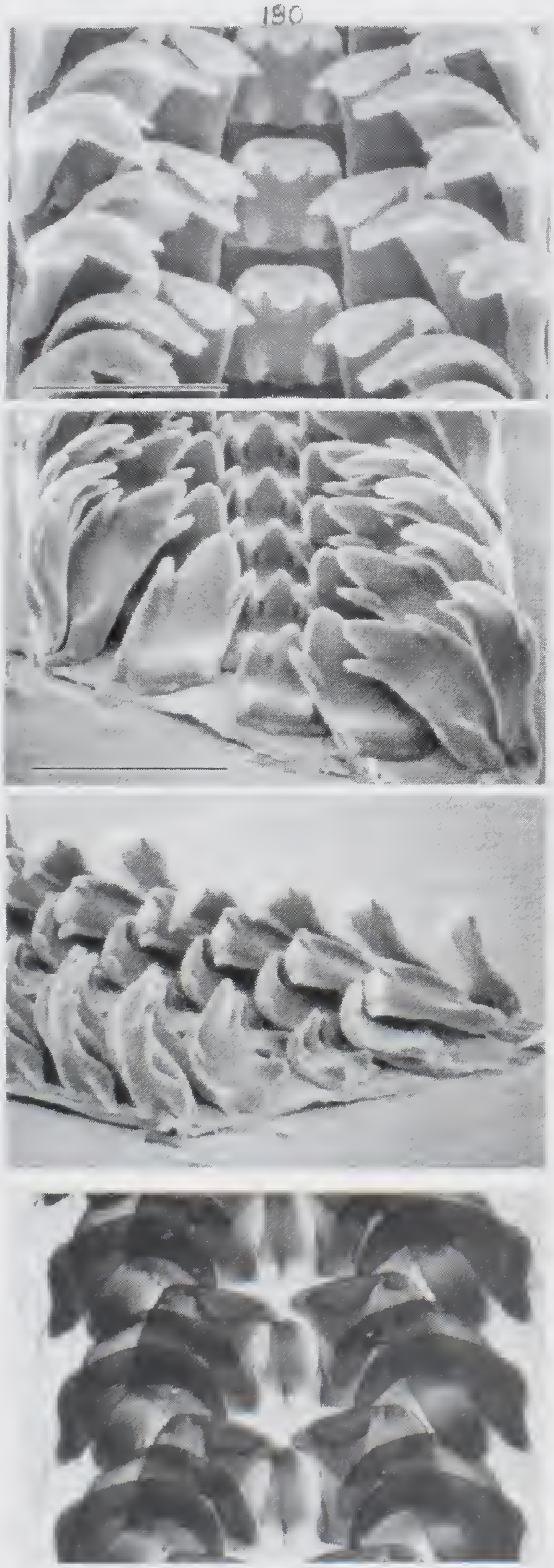


Figure 126. *Zonaria sanguinolenta*

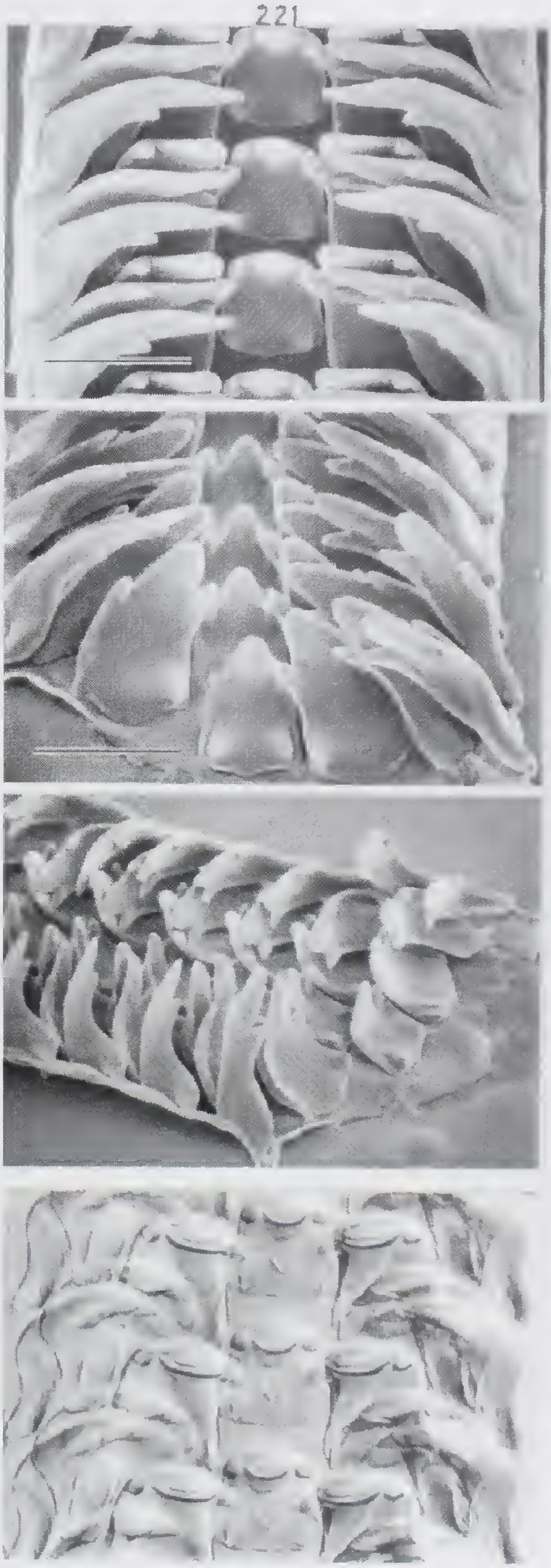


Figure 127. *Zonaria zonaria*

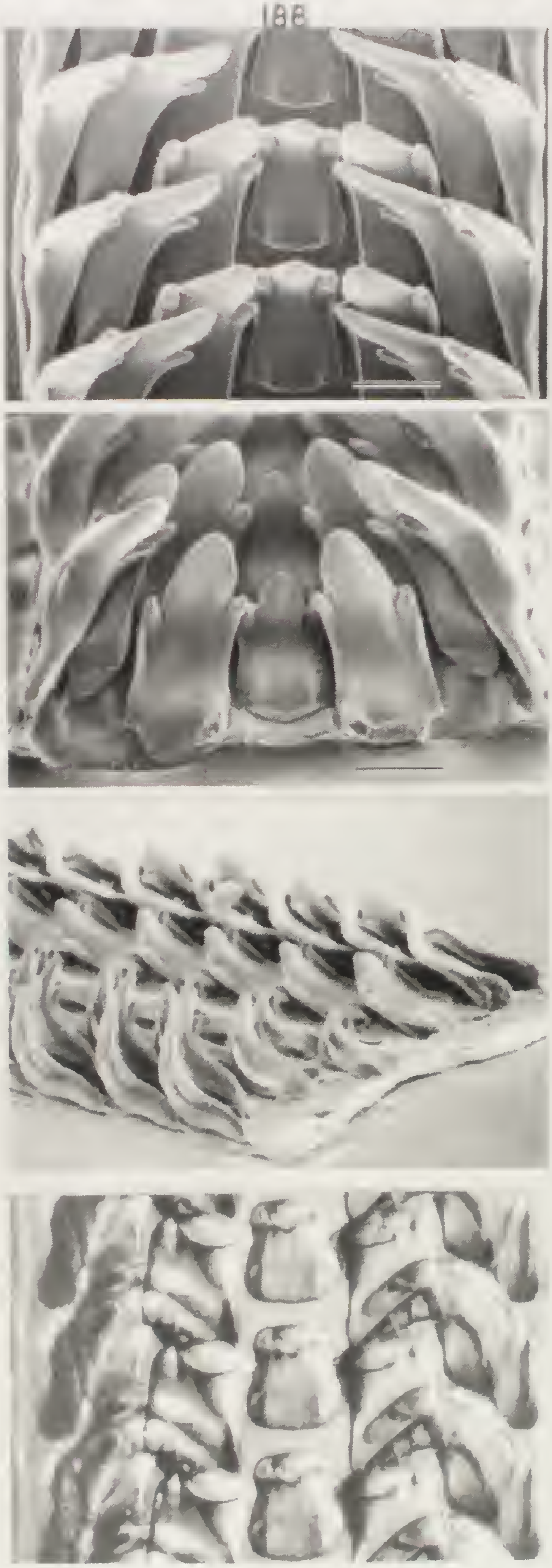


Figure 128. *Zonaria spadicea*

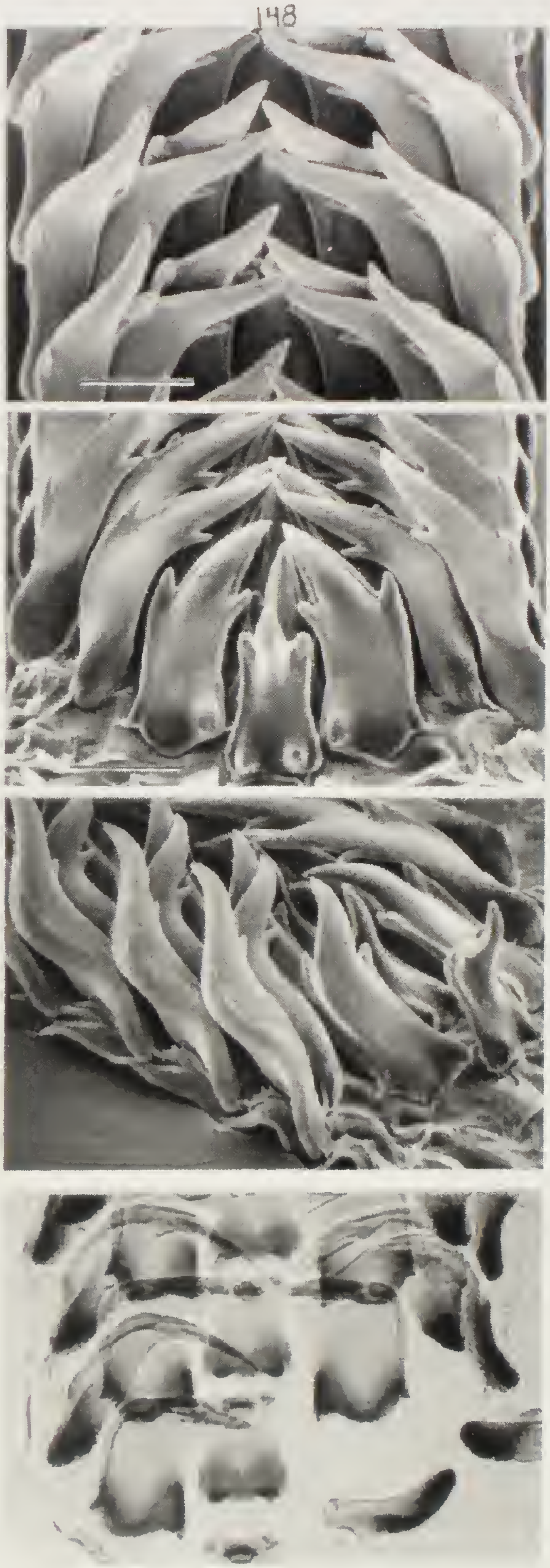
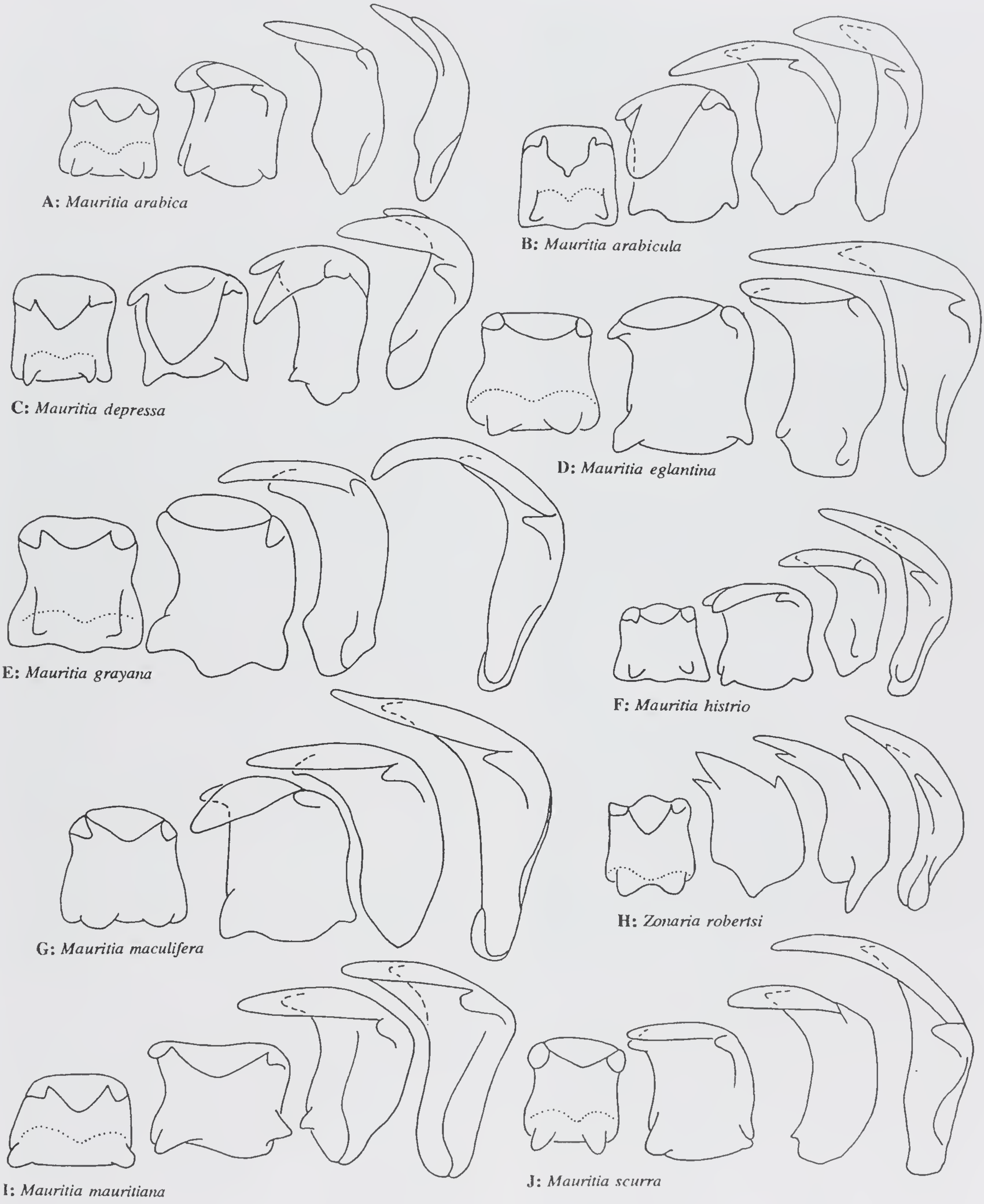


Figure 129. *Zonaria nigropunctata*



A: *Mauritia arabica*

B: *Mauritia arabicula*

C: *Mauritia depressa*

D: *Mauritia eglantina*

E: *Mauritia grayana*

F: *Mauritia histrio*

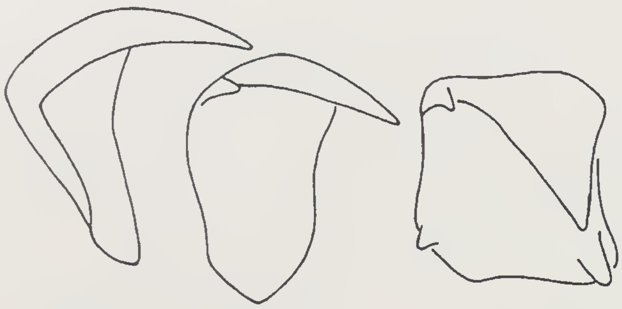
G: *Mauritia maculifera*

H: *Zonaria robertsi*

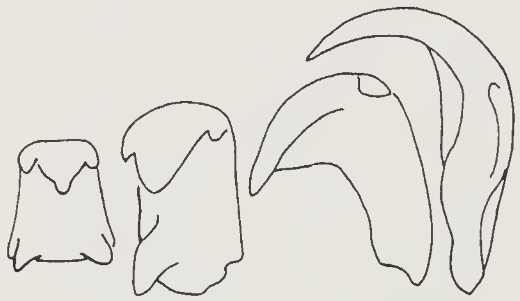
I: *Mauritia mauritiana*

J: *Mauritia scurra*

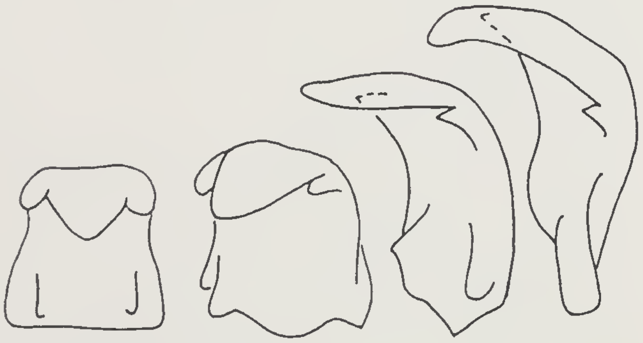
Figure 130. Mauritiana pattern drawings I



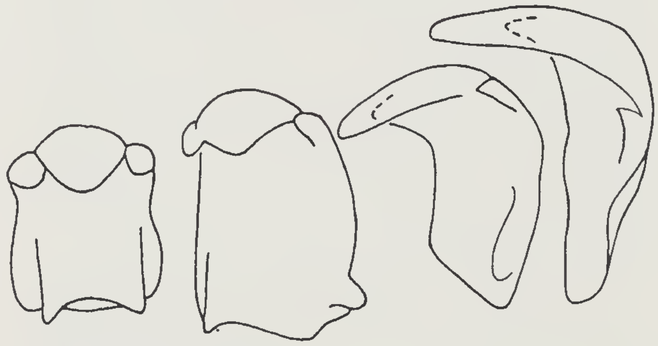
A: *Macrocypraea cervinetta*



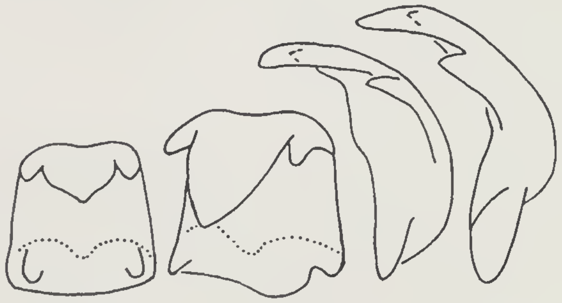
B: *Trona stercoraria*



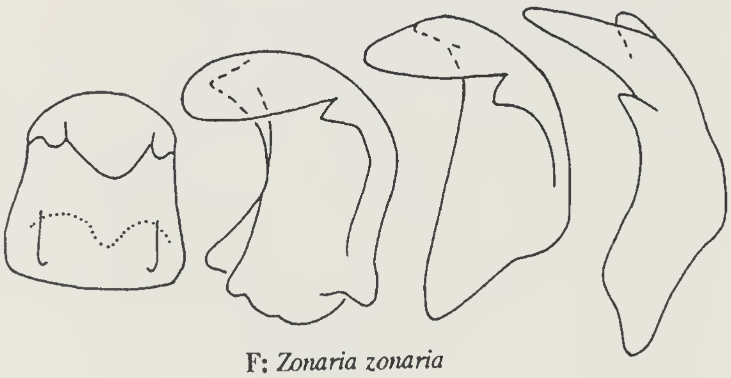
C: *Macrocypraea zebra*



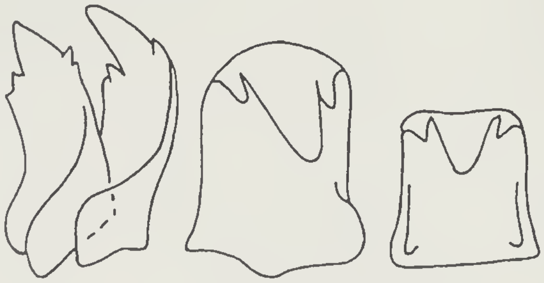
D: *Macrocypraea cervus*



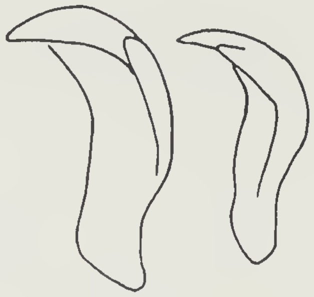
E: *Zonaria pyrum*



F: *Zonaria zonaria*



G: *Zonaria spadicea*



H: *Zonaria spadicea*

Figure 131. Mauritiana pattern drawings II

The Tigris Pattern (Figures 7D, 132-146).
Model species: *Cypraea tigris* Linnaeus, 1758.

Species: *Cypraea mappa* Linnaeus, 1758; *C. pantherina* [Lightfoot, 1786]; *C. tigris* Linnaeus, 1758; *C. valentia* Perry, 1811; *Muracypraea mus* (Linnaeus, 1758); *Umbilia armeniaca* (Verco, 1912); *U. hesitata* (Iredale, 1916); *Zoila decipiens* (Smith 1880); *Z. friendii* (Gray, 1831); *Z. jeaniana* Cate, 1968; *Z. marginata* (Gaskoin, 1849); *Z. rosselli* Cotton, 1948; *Z. venusta* (Sowerby, 1846).

The radular teeth in the tigris pattern are massive (mean central tooth dimensions 316x321 microns (n=8) in *Cypraea*; 330x280 microns (n=4) in *Umbilia*; 251x258 microns (n=11) in *Zoila*). The central tooth of *U. armeniaca* at 355x370 microns was the largest tooth we measured. The teeth are heavily chitinized, evenly spaced and well separated with little overlap between laterals and marginals. The central tooth is tricuspid, the apex distinctly curved, slightly longer than wide except for *Zoila* (mean l/w ratio 0.91; n=11); (1.16 (n=8) in *Cypraea*; 1.19 (n=3) in *Umbilia*); with a heavily staining internal bract, and paired basal denticles projecting below the basal platform in the four cypraeids, and in most of the Australian species. The laterals are about the same size as the central, each with a single basal denticle on the inner corner. The marginals are tricuspid, the central cusp bladelike; the shaft of the inner marginal is equal in breadth to the lateral but narrow in the outer marginal except in *C. valentia*.

Central tooth dimensions: 405x380 to 170x200 microns (n=8) in *Cypraea*; 185x170 microns for one specimen of *Muracypraea mus*; 250x250 to 430x365 microns (n=3) for *Umbilia*; 155x165 to 355x270 microns (n=11) for *Zoila*.
No. of radular rows: 90 to 200 (n=4) in *Cypraea*; 85 to 120 (n=4) in *Umbilia*; 110 to 175 (n=5) in *Zoila*.
No. radular rows per mm radula: 2.8 to 5.9 (n=7) in *Cypraea*; 2.6 to 3.1 (n=2) in *Umbilia*; 3.4 to 13 (n=11) in *Zoila*.

Tigris pattern species are circumtropical: the four species of *Cypraea* occur in the Indo-West Pacific, *Umbilia* and *Zoila* are endemic to Australia, and *Muracypraea mus* is endemic to the Caribbean. The fossula is broad and ridged in *Cypraea*, smooth in *Zoila* and *Muracypraea*, virtually nonexistent in *Umbilia*. There is a bursa copulatrix in the females of *Cypraea*, *Muracypraea* and *Zoila*. The larval shells in *Cypraea* indicate a planktonic larval stage; development is direct in *Muracypraea*, *Umbilia* and *Zoila*. *Cypraea* is reported from the late Miocene of Indonesia, *Muracypraea* from the early Miocene of the Caribbean; *Umbilia* from the late Oligocene, and *Zoila* from the early Eocene of Australia.

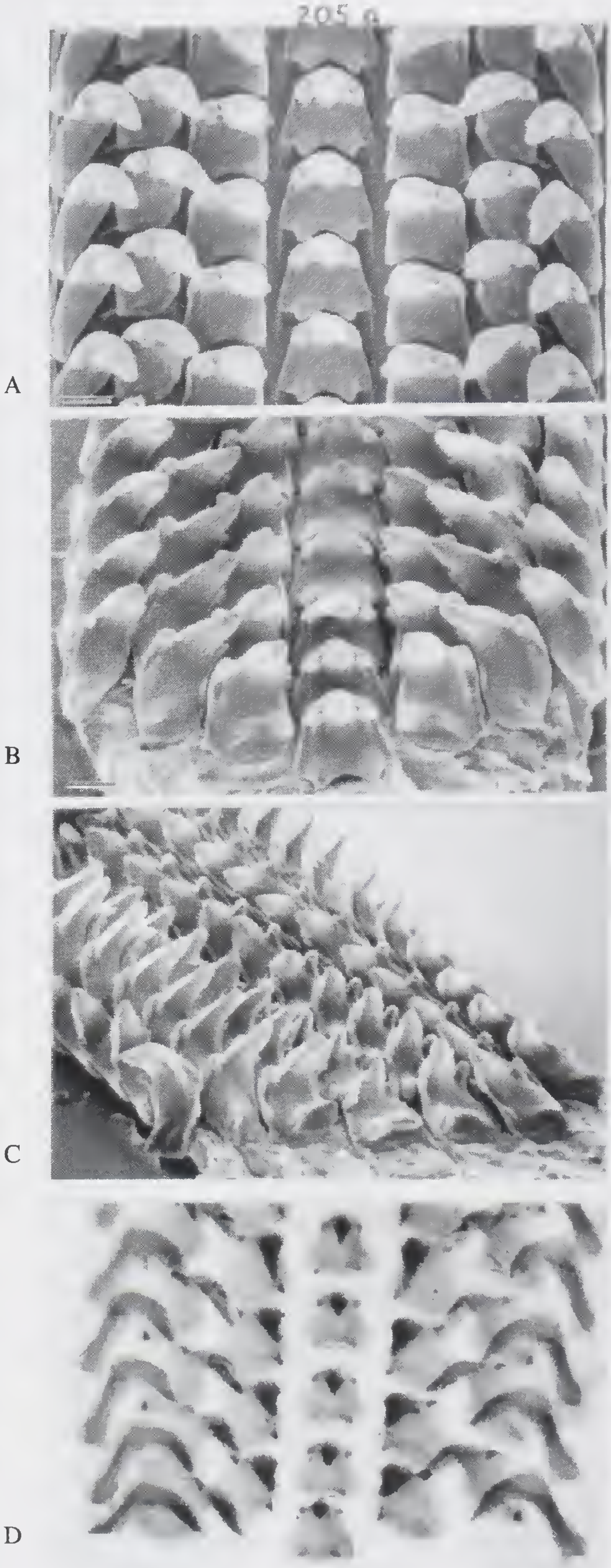


Figure 132. *Cypraea tigris*

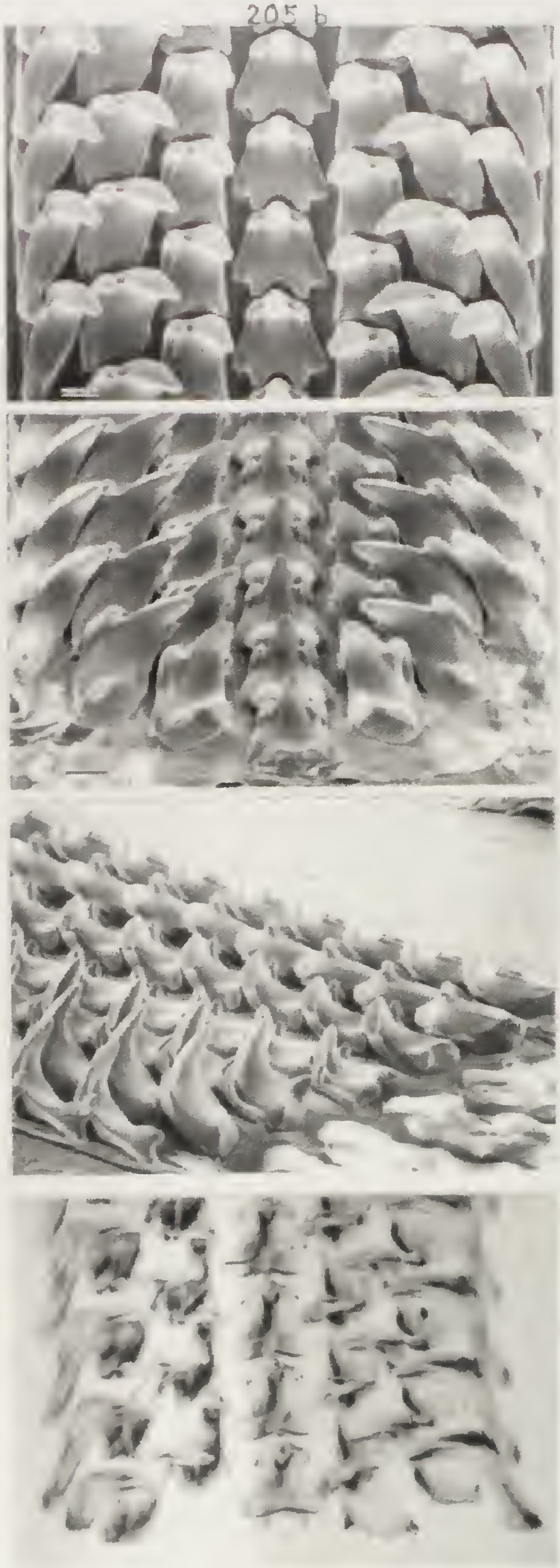


Figure 133. *Cypraea tigris schilderiana*

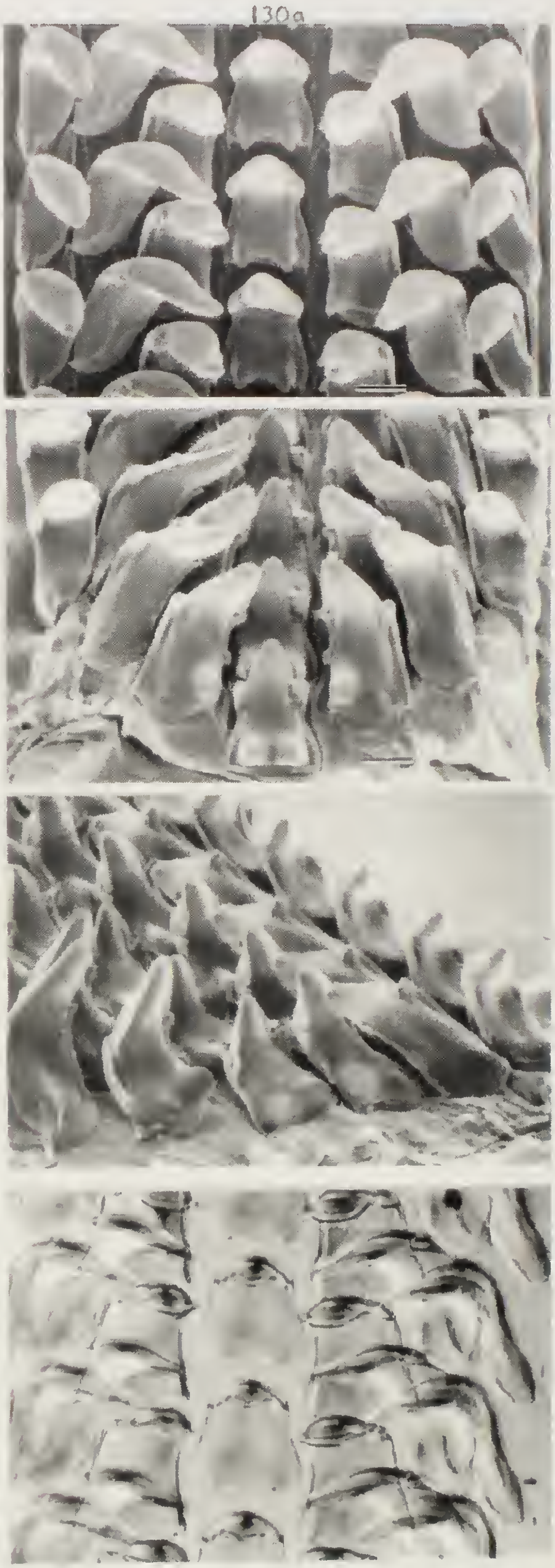


Figure 134. *Cypraea mappa*

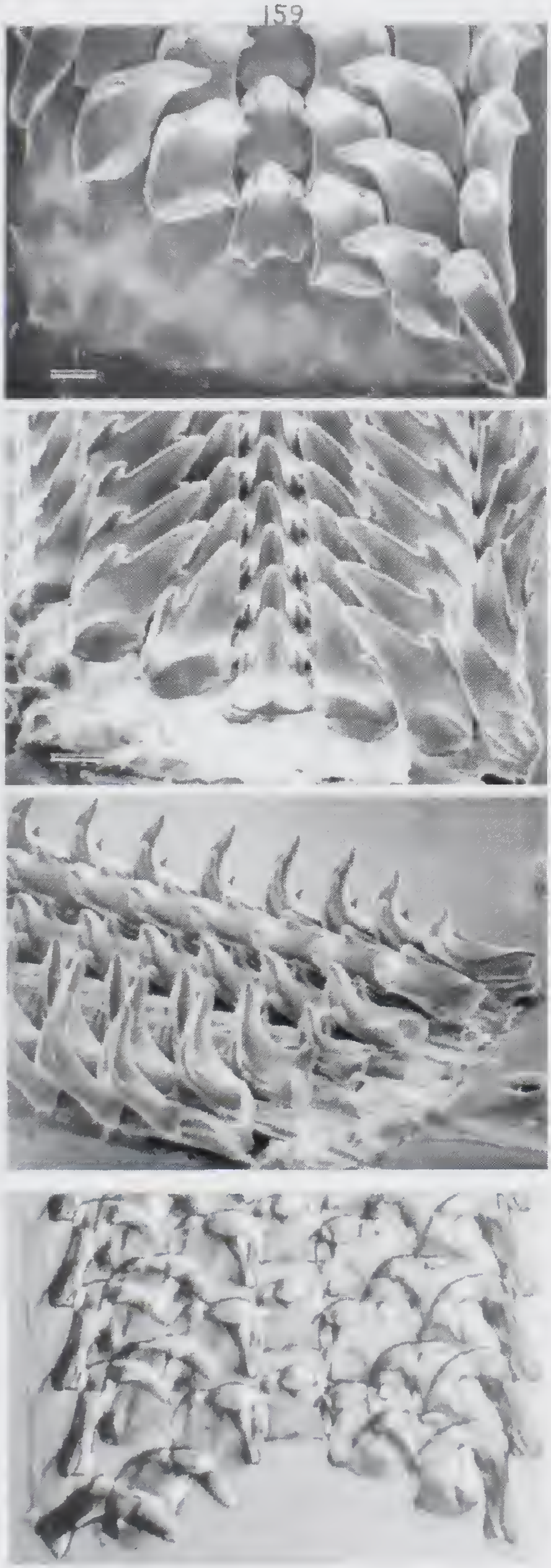


Figure 135. *Cypraea pantherina*

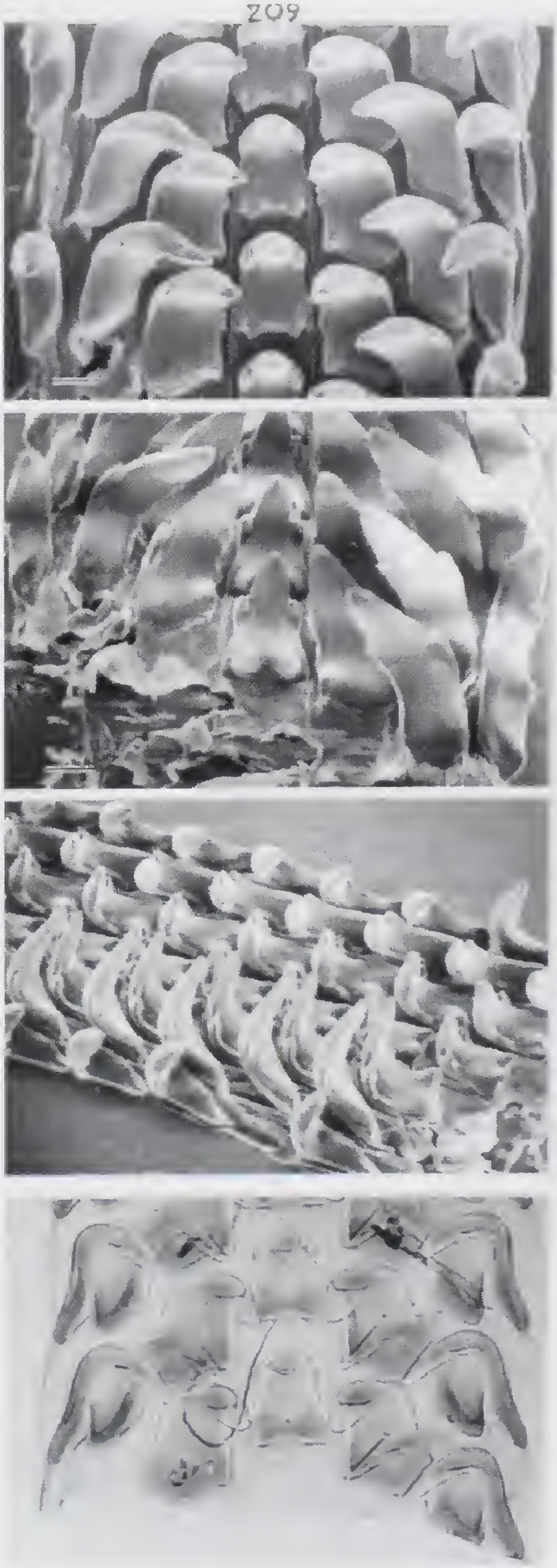


Figure 136. *Cypraea valentia*

145

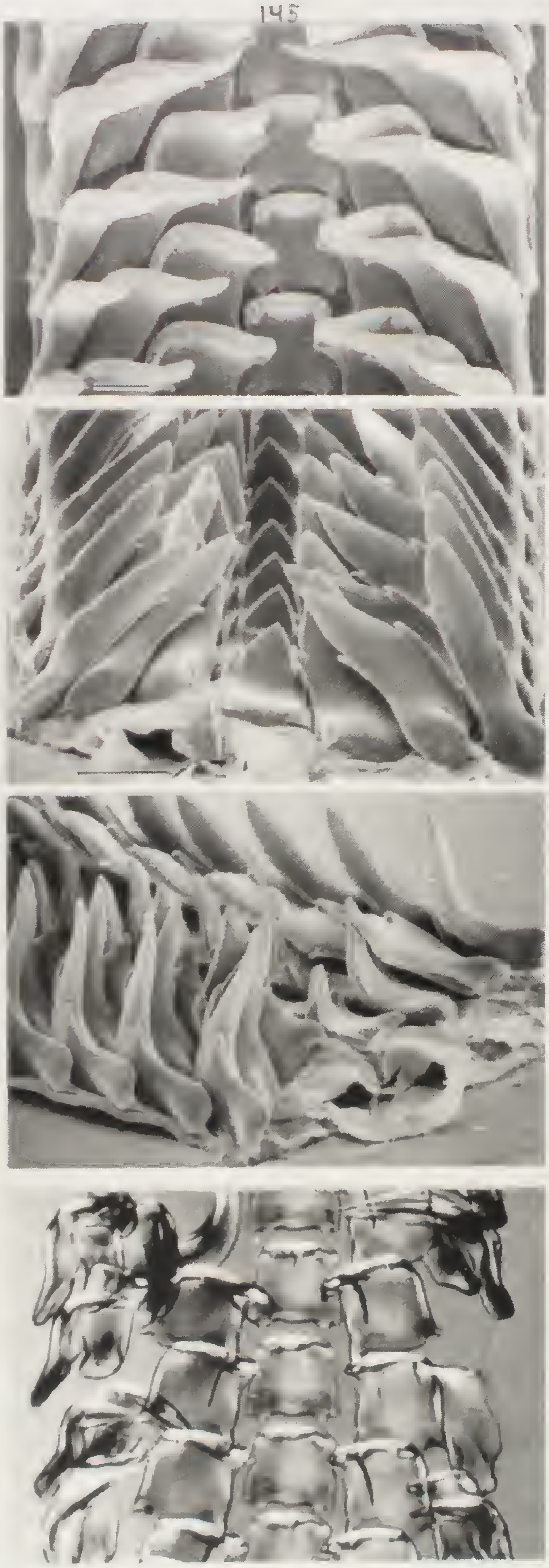


Figure 137. *Muracypraea mus*

15

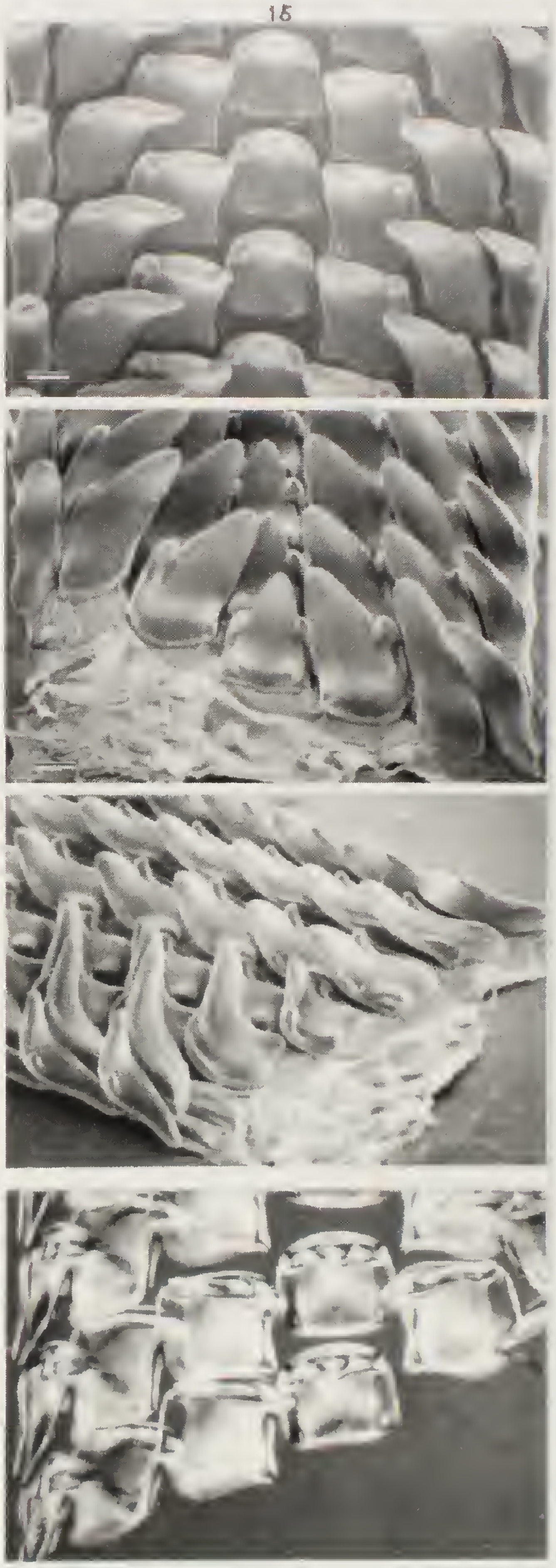


Figure 138. *Umbilia armeniaca*

97

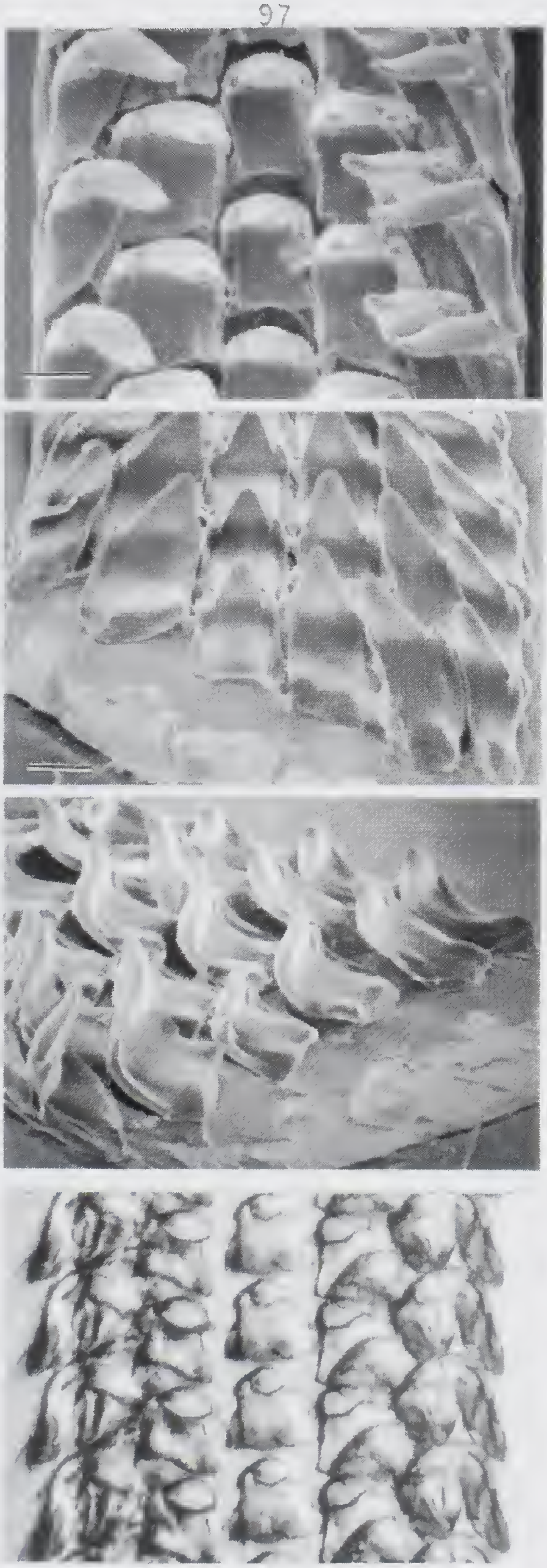


Figure 139. *Umbilia hesitata*

63

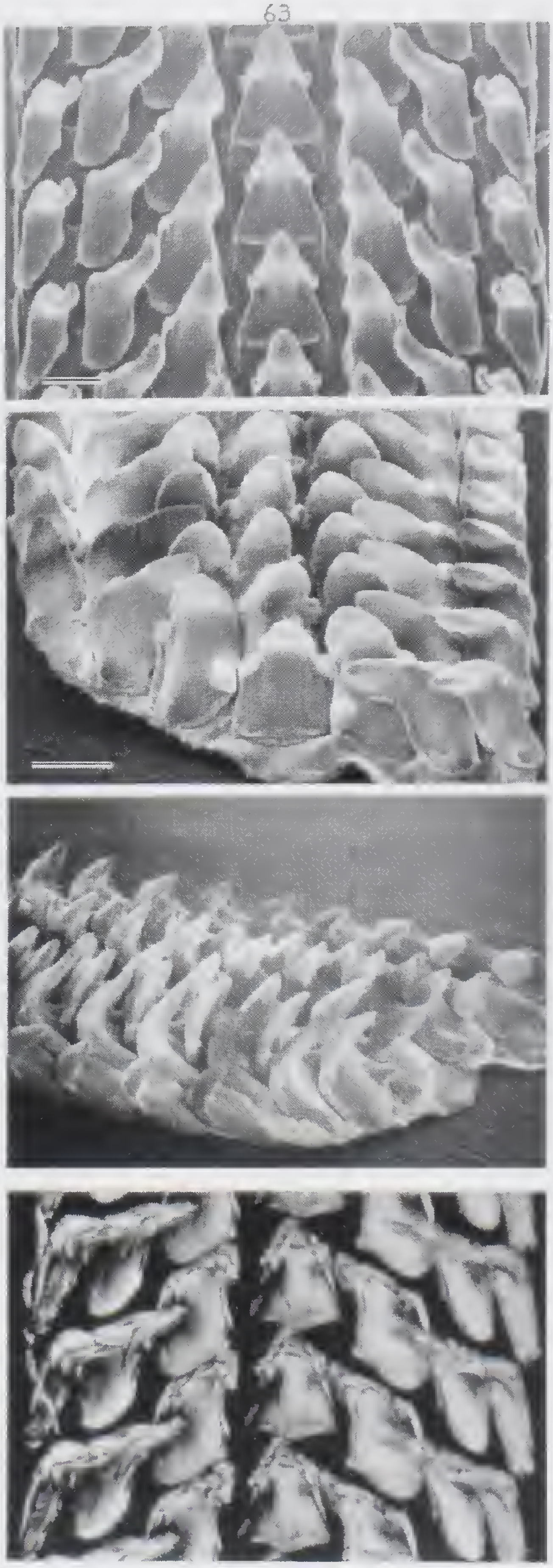


Figure 140. *Zoila decipiens*

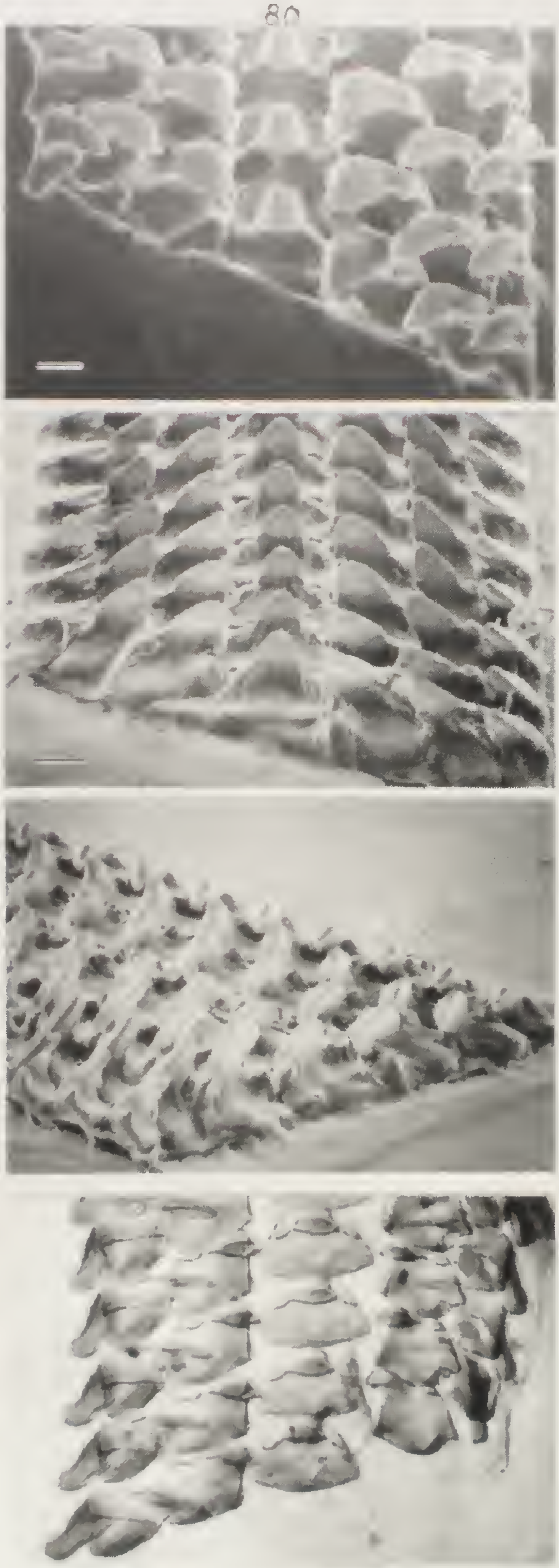


Figure 141. *Zoila friendii*

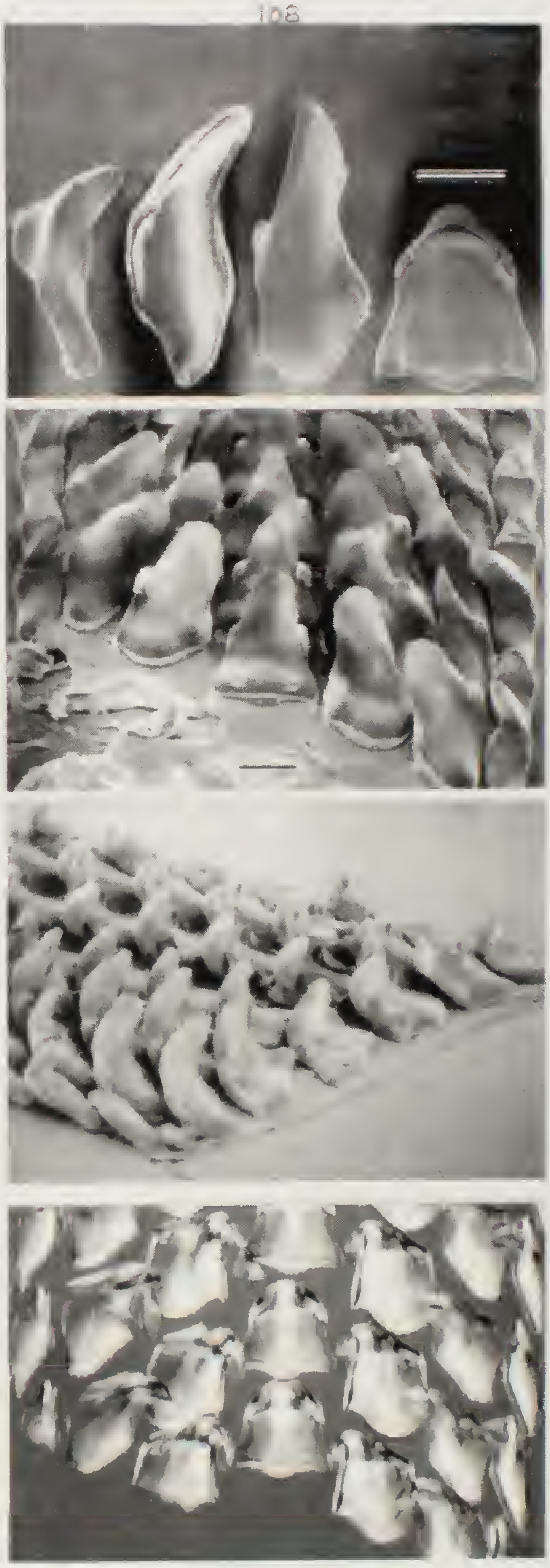


Figure 142. *Zoila jeaniana*

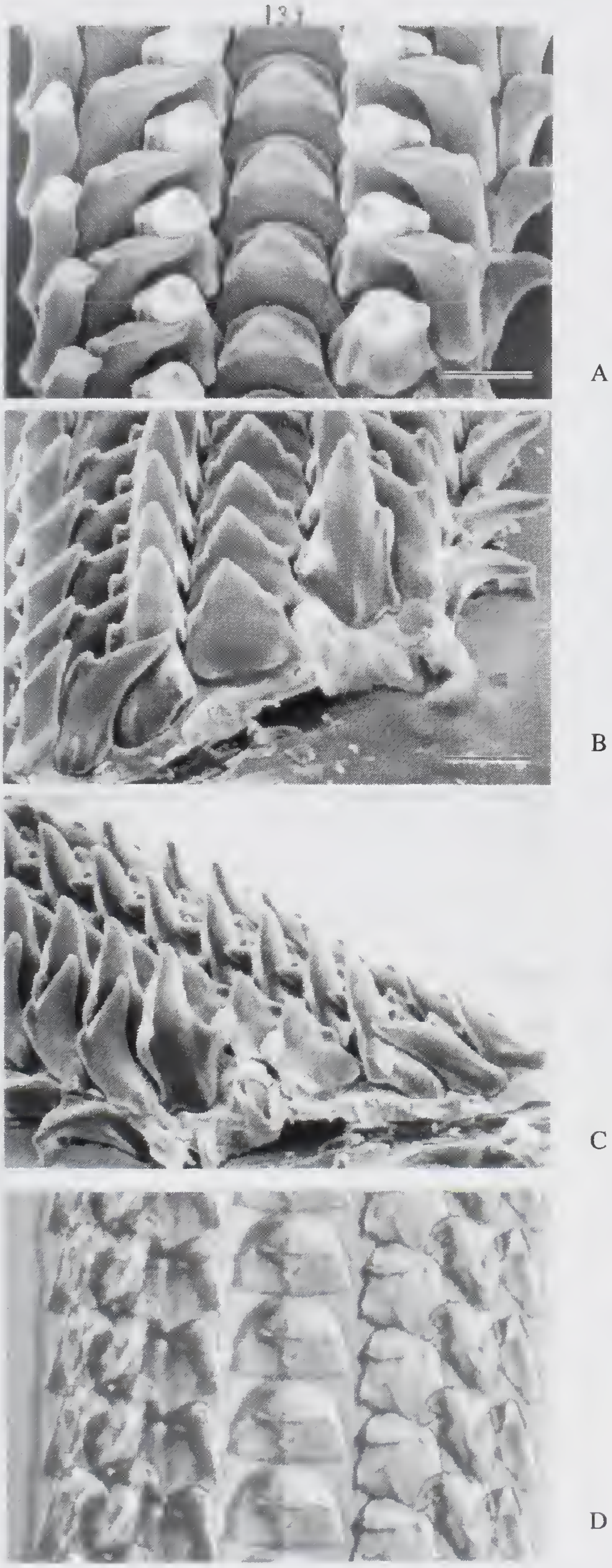


Figure 143. *Zoila marginata*

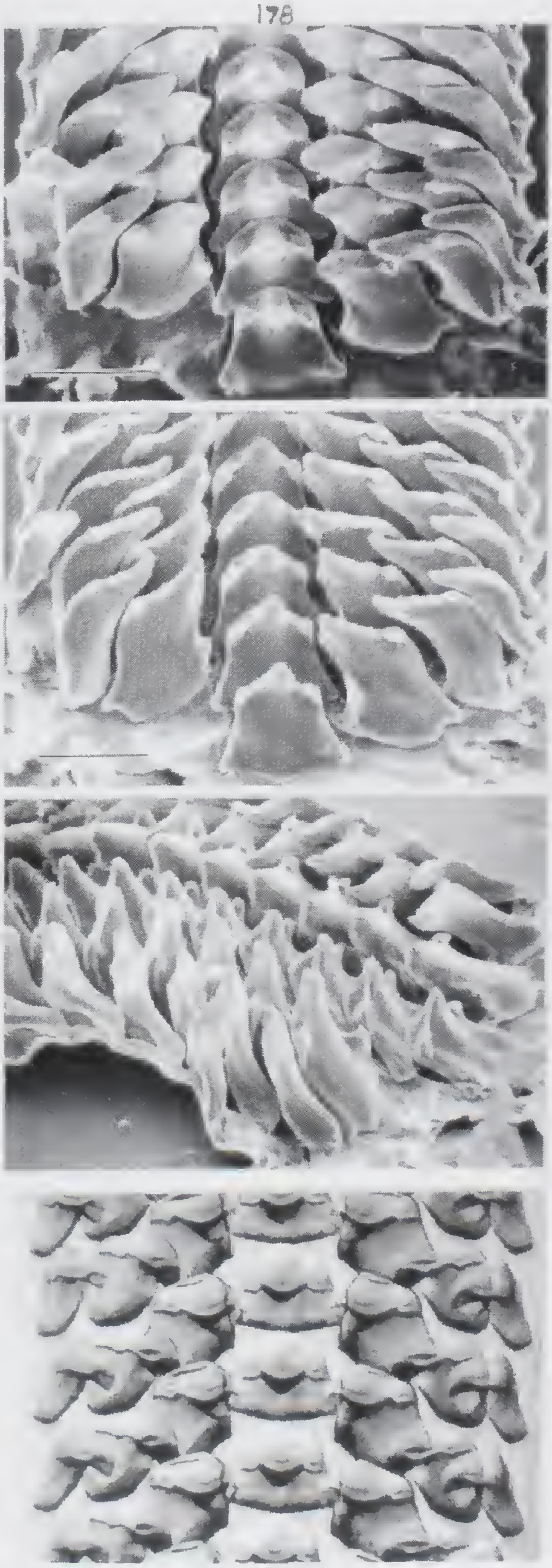


Figure 144. *Zoila rosselli*

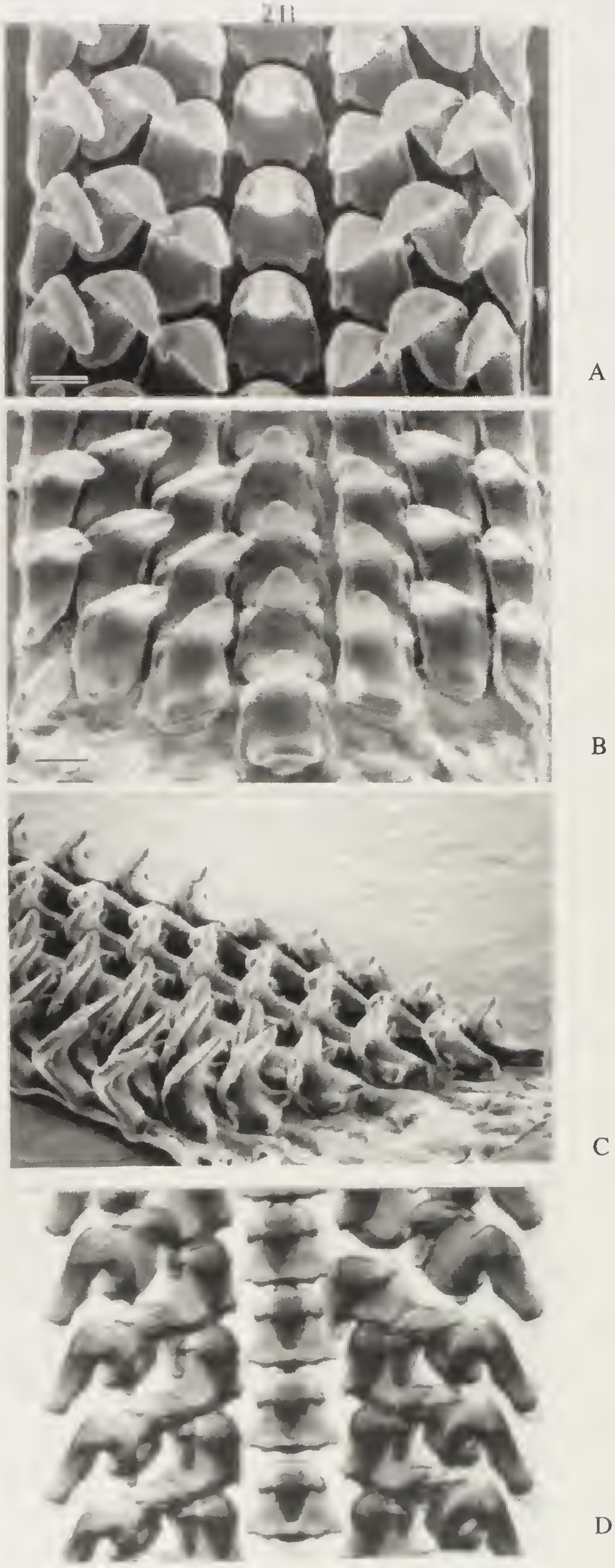
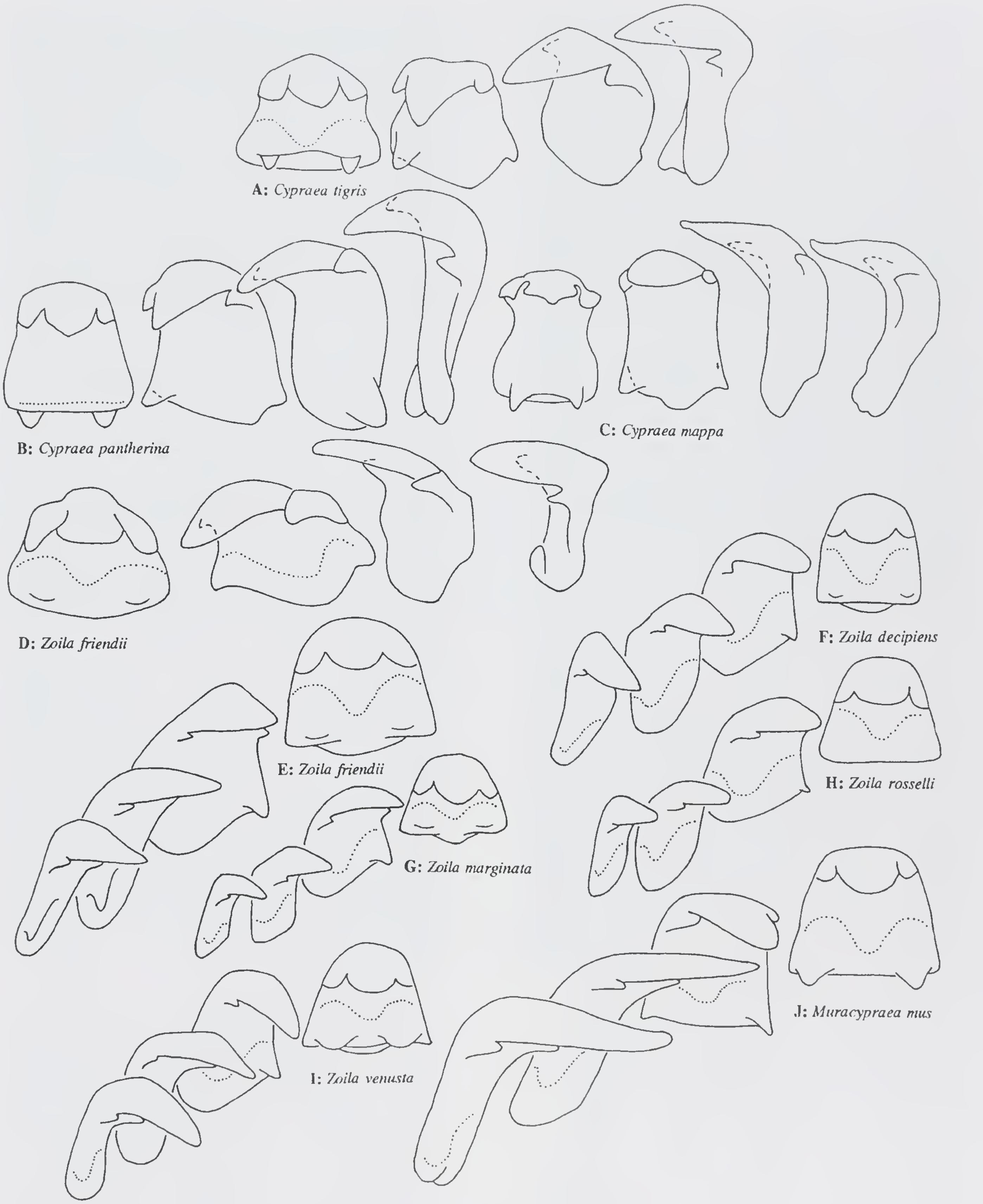


Figure 145. Zoila venusta



A: *Cypraea tigris*

B: *Cypraea pantherina*

C: *Cypraea mappa*

D: *Zoila friendii*

E: *Zoila friendii*

F: *Zoila decipiens*

G: *Zoila marginata*

H: *Zoila rosselli*

I: *Zoila venusta*

J: *Muracypraea mus*

Figure 146. Tigris pattern drawings

The Isabella Pattern (Figures 147-153).
Model Species: *Luria isabella* (Linnaeus, 1758).

Species: *Luria cinerea* (Gmelin, 1791); *L. isabella* (Linnaeus, 1758); *L. isabellamexicana* (Stearns, 1893); *L. lurida* (Linnaeus, 1758); *L. pulchra* (Gray, 1824); *L. tessellata* (Swainson, 1822).

The radular teeth in the isabella pattern are distinguished by their precise arrangment in rows, each tooth noticeably separate from the others, with neither marginals nor laterals overlapping. The central tooth in the isabella pattern is surprisingly large (mean dimensions 185x185 microns; n=14) and is conspicuously larger than the laterals and the marginals, about equally as long as it is wide (mean l/w ratio 1.03; n=14), tricuspid, with a dark staining internal bract and the basal corners forming minor denticles. There is no subtending bract. A single denticle near the base of each of the lateral teeth is oriented toward the marginals. The marginals are tricuspid, each with a single basal denticle. The outer marginal is nearly vestigial in some specimens.

Central tooth dimensions: 70x110 to 320x335 microns (n=14).
No. of radular rows: 90 to 250 (n=12).
No. of radular rows per mm radula: 4.9 to 12.2 (n=10).

The six Recent species referred to *Luria* by M. Schilder & F. Schilder (1971) all display this distinctive pattern. Four species are Indo-West Pacific in distribution; *L. cinerea* occurs in the Caribbean, Atlantic and Mediterranean, and *L. isabellamexicana* is found on the west coast of the Americas. These cowries are characterized by cylindrical to pyriform shells; a broad, usually smooth fossula except for a fringe of indentations on the internal margin; black to light brown, virtually non-papillose mantle, a bursa copulatrix in the females, and a characteristically tear-drop shaped larval shell. The fossil history of the group is known from the early Miocene of Fiji.

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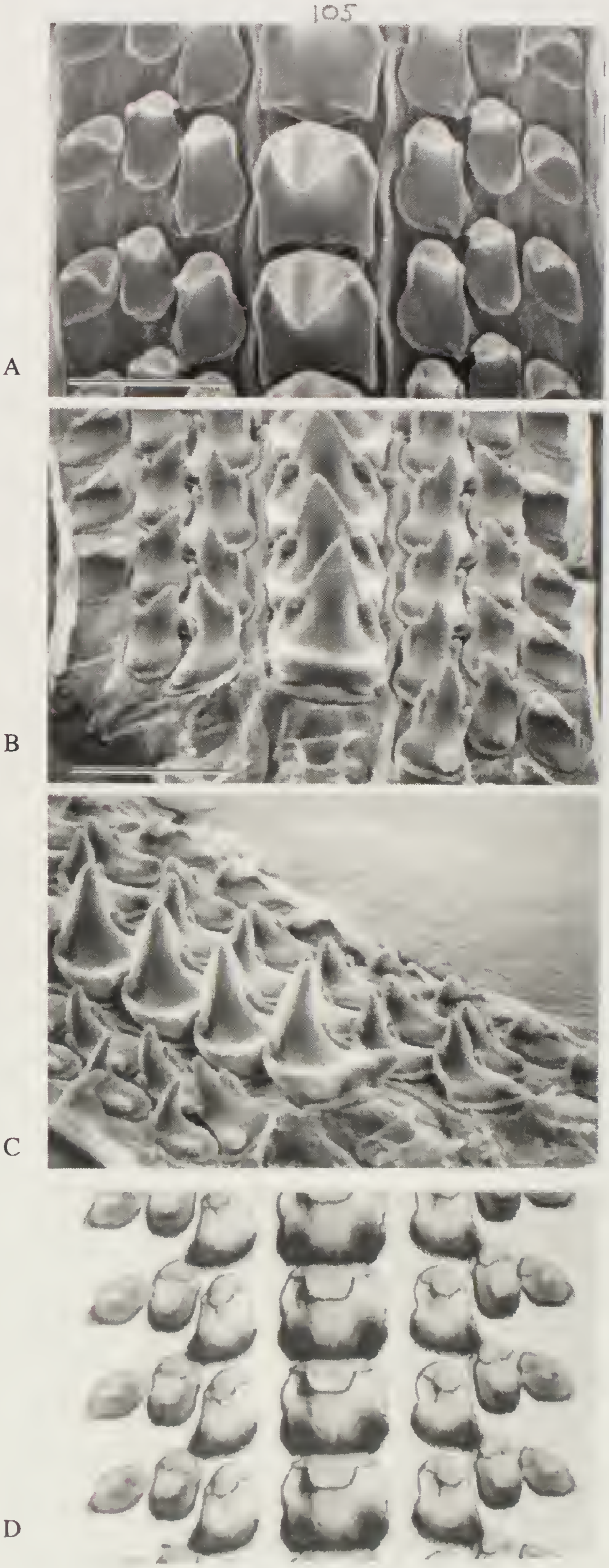


Figure 147. *Luria isabella*

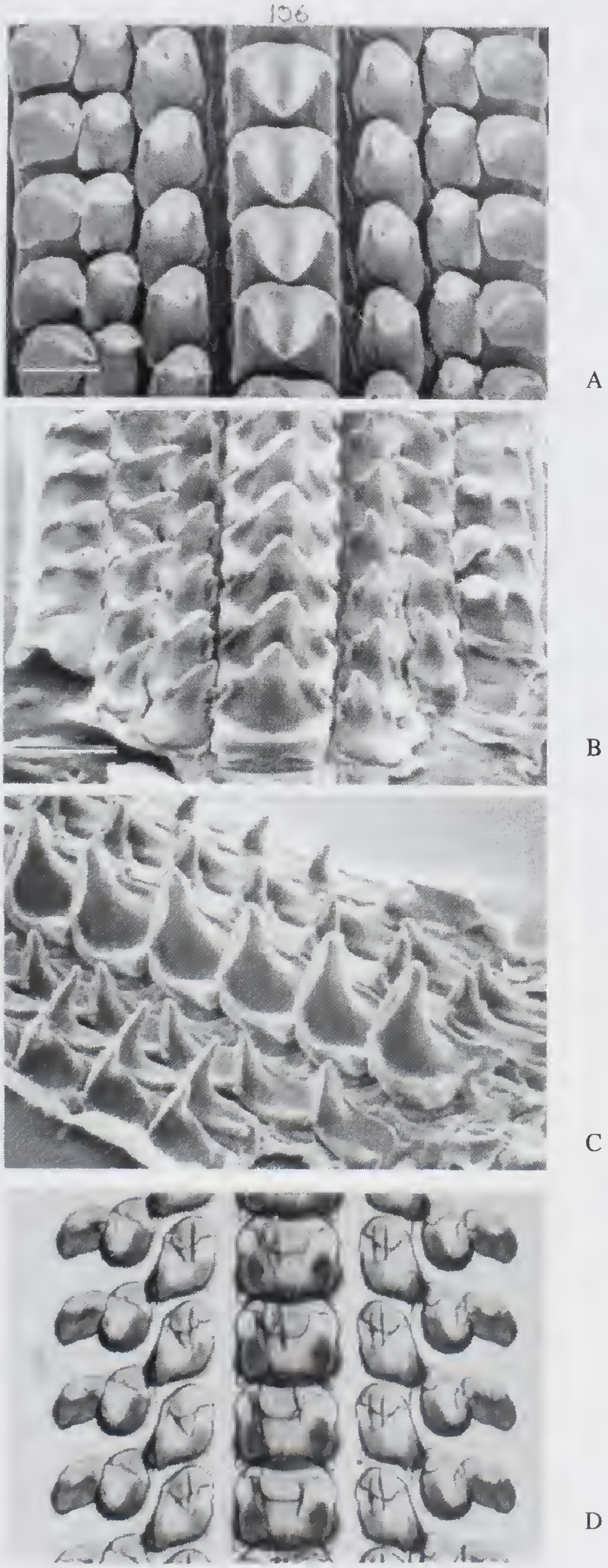


Figure 148. *Luria isabellamexicana*

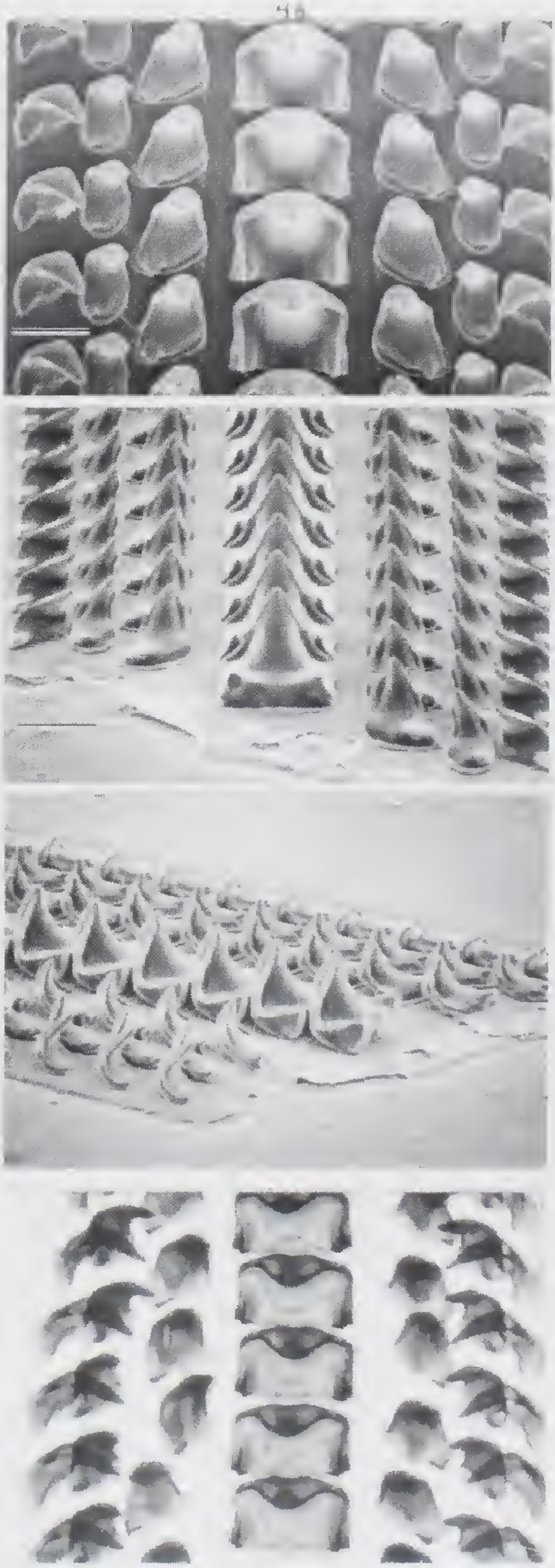


Figure 149. *Luria cinerea*

124

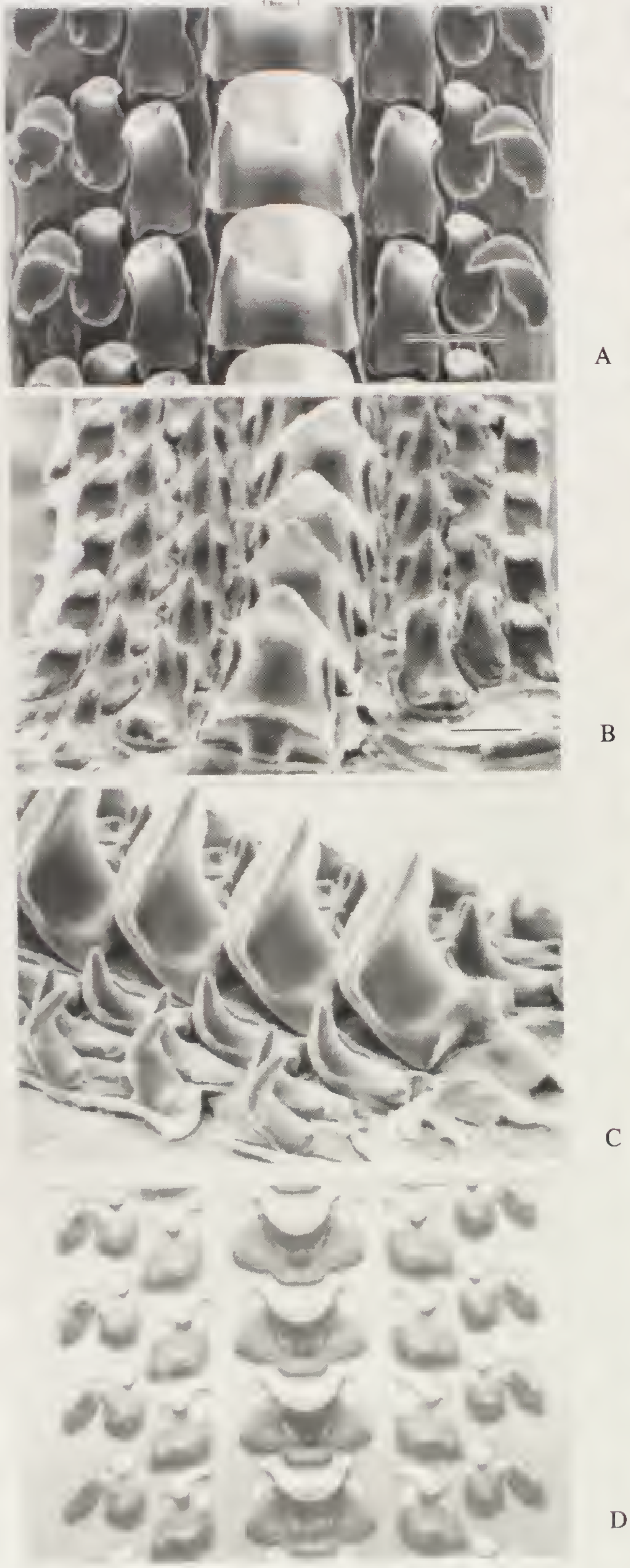


Figure 150. *Luria lurida*

167

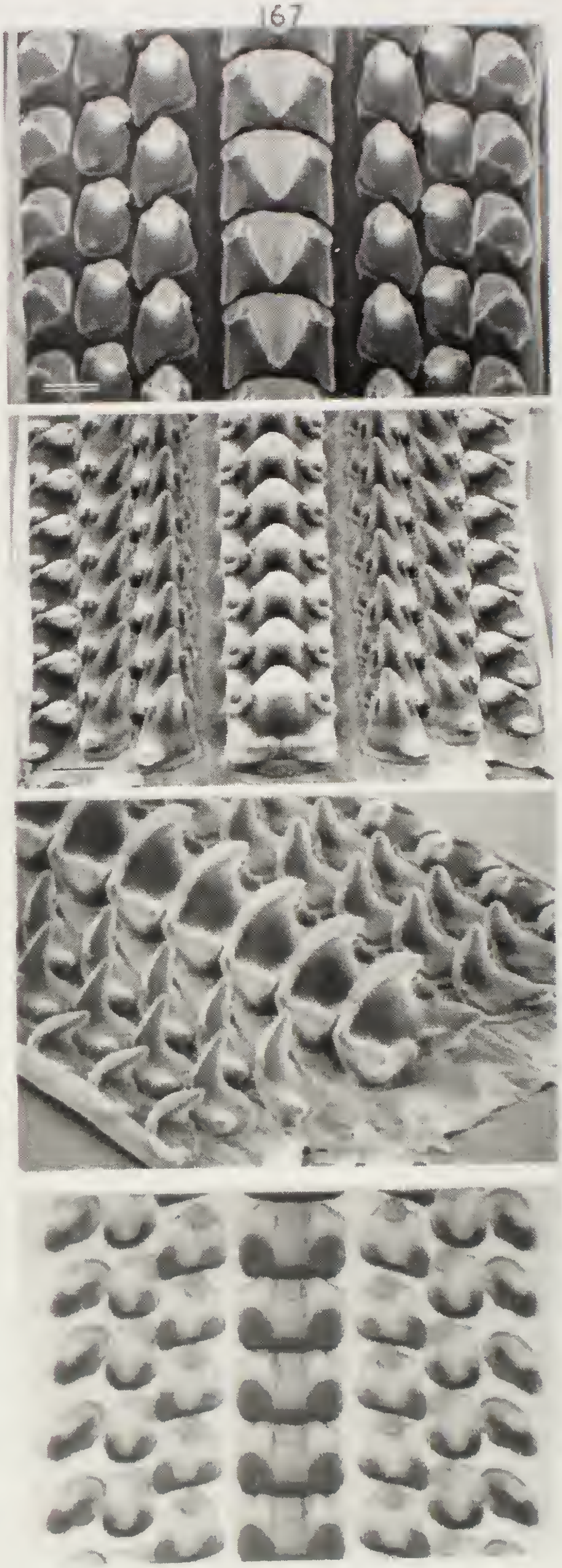


Figure 151. *Luria pulchra*

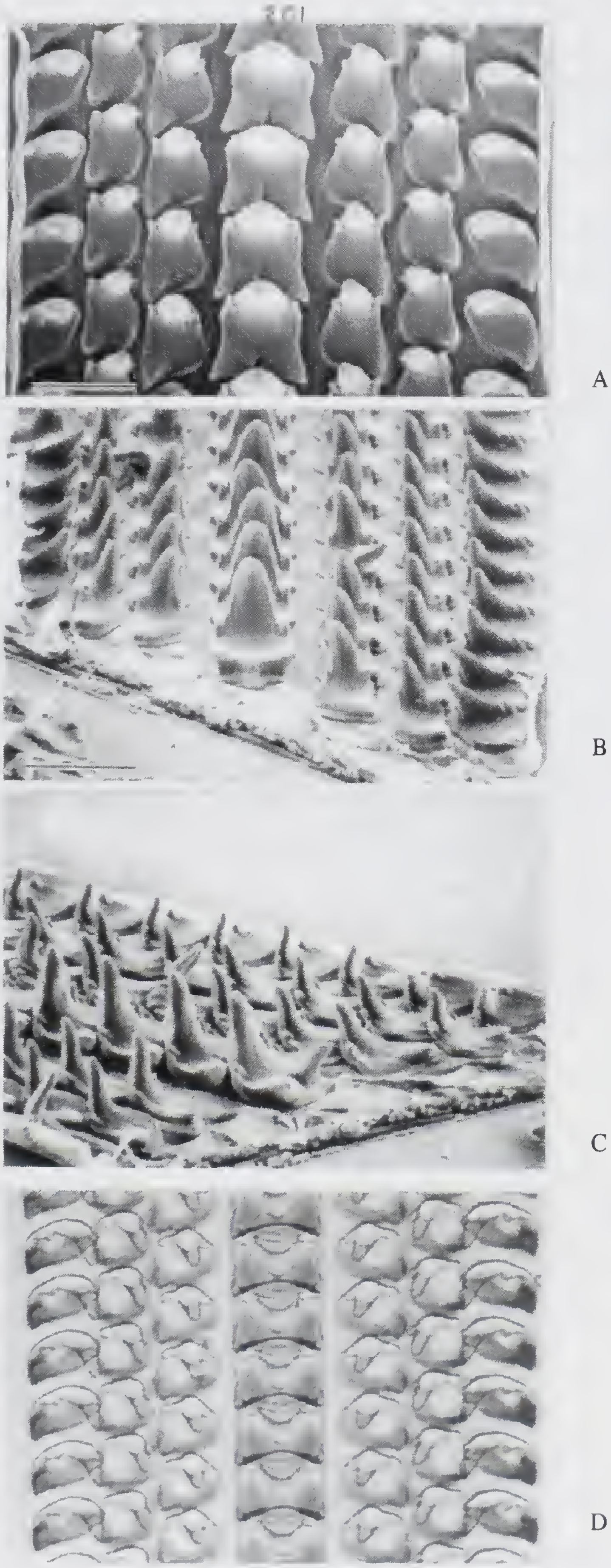
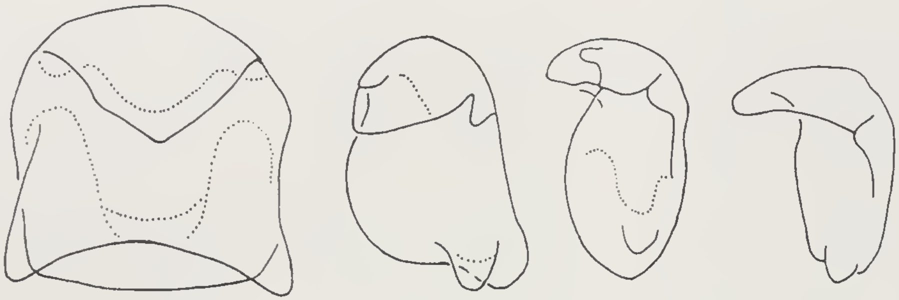
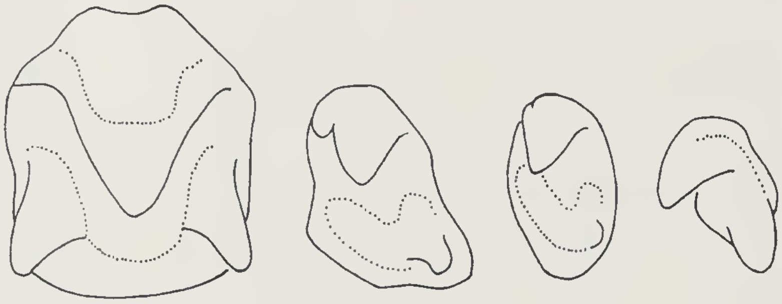


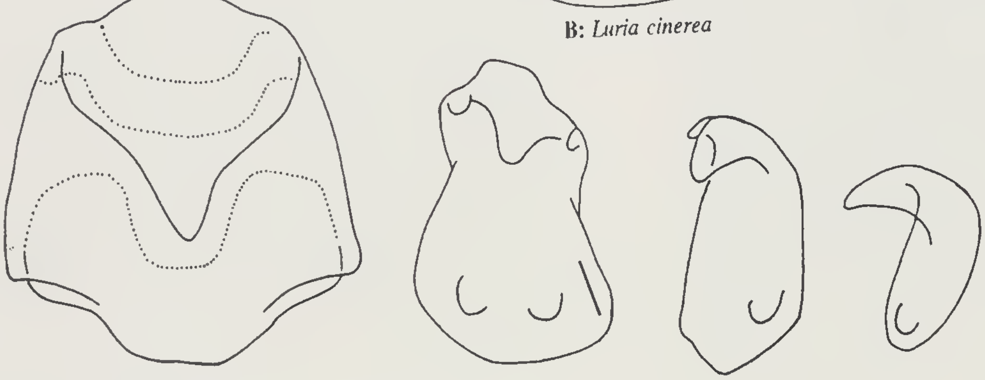
Figure 152. *Luria tessellata*



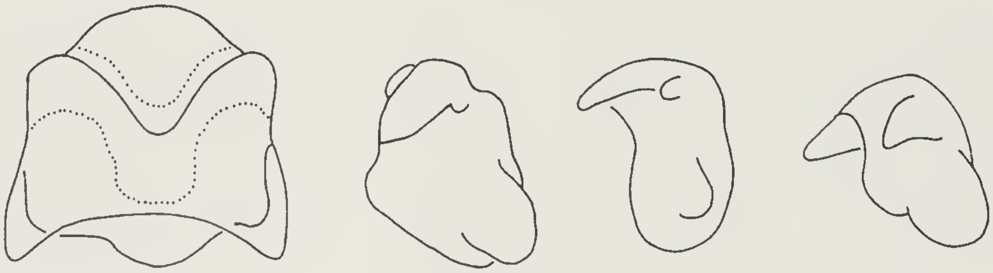
A: *Luria isabella*



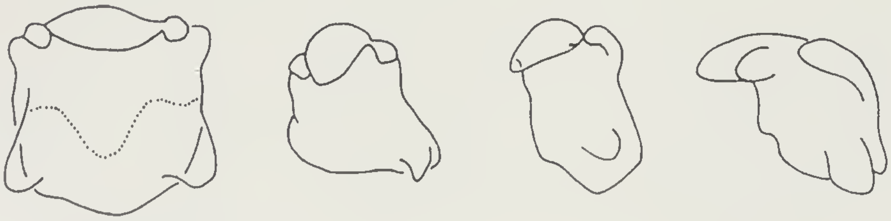
B: *Luria cinerea*



C: *Luria lurida*



D: *Luria pulchra*



E: *Luria tessellata*

Figure 153. Isabella pattern drawings

The Achatidea Pattern (Figures 154-175).

Model species: *Schilderia achatidea* (Sowerby, 1837).

Species: *Barycypraea fultoni* (Sowerby, 1903); *B. teulerei* (Cazanavette, 1846); *Cypraeovula alfredensis* (F. Schilder & M. Schilder, 1929); *C. algoensis* (Gray, 1825); *C. capensis* (Gray, 1828); *C. connelli* (Liltved, 1983); *C. coronata* (Schilder, 1930); *C. cruickshanki* (Kilburn, 1972); *C. edentula* (Gray, 1825); *C. fuscodentata* (Gray, 1825); *C. fuscorubra* (Shaw, 1909); *C. gondwanalandensis* (Burgess, 1970); *C. iutsui* Shikama, 1974; *C. mikeharti* Lorenz, 1985; *Nesiocypraea hirasei* (Roberts, 1913); *N. langfordi* (Kuroda, 1938); *N. midwayensis* Azuma & Kurohara, 1967; *N. sakuraii* (Habe, 1970); *N. teramachii* (Kuroda, 1938); *Schilderia achatidea* (Sowerby, 1837).

Distinguishing features of the achatidea pattern include central teeth as much as 1.6 times as long as they are wide and with a pair of longitudinal ridges mid-shaft visible by OM but which with SEM are in the form of paired denticles. The arched anterior edge of the central tooth is also characteristic. As in the isabella pattern, the central tooth is large, with 60 percent of the specimens more than 200 microns in length (mean central tooth dimensions are 280x180 microns (n=2) in *Barycypraea*, 193x144 microns (n=16) in *Cypraeovula*, and 251x201 microns (n=7) in *Nesiocypraea* and *Schilderia*). Teeth are well spaced, the marginals barely overlapping. The central tooth is tricuspid, wider at the base than at the apex; with an internal bract but no subtending bract. The marginals approximate the size of the central tooth and bear a prominent denticle oriented toward the central tooth; the base of the marginals is narrow, and the cusps are bladelike in profile. Drawings of the teeth of the deep water cowries such as *N. langfordi* and the South African cowries (Gosliner & Liltved, 1985; Barnard, 1963; Kilburn, 1972; Kilburn & Aiken, 1972) illustrate ridges on the shaft of the central and lateral teeth but no basal denticles (see *C. iutsui*, Figure 107), nor are denticles detectable in specimens processed for OM. In specimens prepared for SEM, however, the ridges depicted (for example in *C. capensis*, Figure 32) clearly terminate in denticles.

Central tooth dimensions: 55x130 to 305x230 microns (n=2) in *Barycypraea*; 100x90 to 285x205 microns (n=15) in *Cypraeovula*; and 110x120 to 405x250 microns (n=7) in *Nesiocypraea* and *Schilderia*.

No. of radular rows: 66 to 110 (n=11) in *Cypraeovula*; 83 to 110 (n=3) in *Nesiocypraea* and *Schilderia*.

No. of radular rows per mm radula: 3.9 to 10.3 (n=11) in *Cypraeovula;* 3.5 to 4.7 (n=5) in *Nesiocypraea* and *Schilderia.*

The two species of *Barycypraea*, the twelve species of *Cypraeovula* and the six species of *Nesiocypraea* and *Schilderia* characterized by this radula pattern, are fairly restricted in occurrence: *Barycypraea* and *Cypraeovula* are found off the coast of southern Africa, *S. achatidea* is a West African and western Mediterrancean species, and the remaining species are associated with deep water off the coasts of the Philippines, Taiwan, southern Japan and southern Africa. The shells are pyriform to ovate in *Cypraeovula* and *Schilderia*, rostrate in *Nesiocypraea*, and the margins are depressed in *Barycypraea*. The fossula in *S. achatidea* and *Nesiocypraea* is spoon shaped and smooth except for the scalloped internal edge; it is smooth in *Barycypraea,* and scalloped and irregularly ridged in *Cypraeovula*. A bursa copulatrix is present in the females of *C. capensis*, absent in *Nesiocypraea*. Pleistocene fossils of *Barycypraea* are known from South Africa; the fossil record of *Schilderia* stems from the early Miocene of southwest France. Fossils of *Cypraeovula* and *Nesiocypraea* have not been reported.

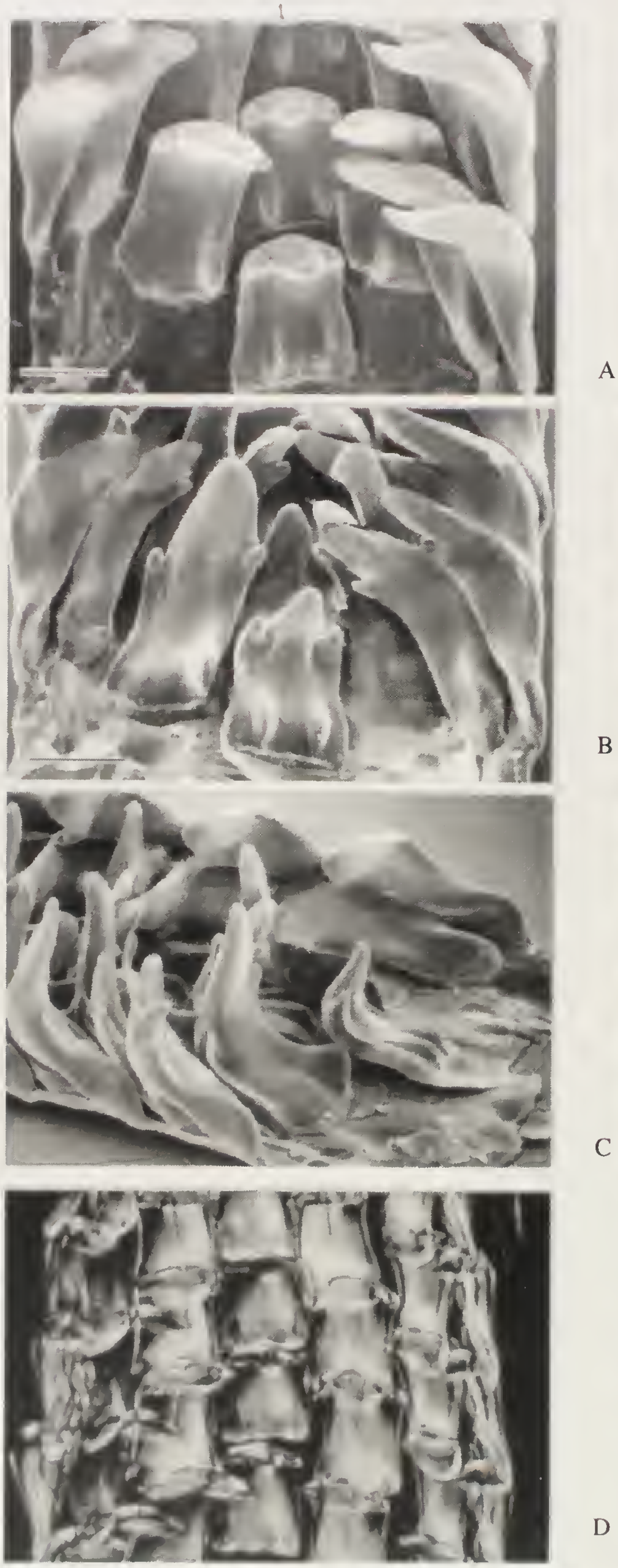


Figure 154. *Schilderia achatidea*

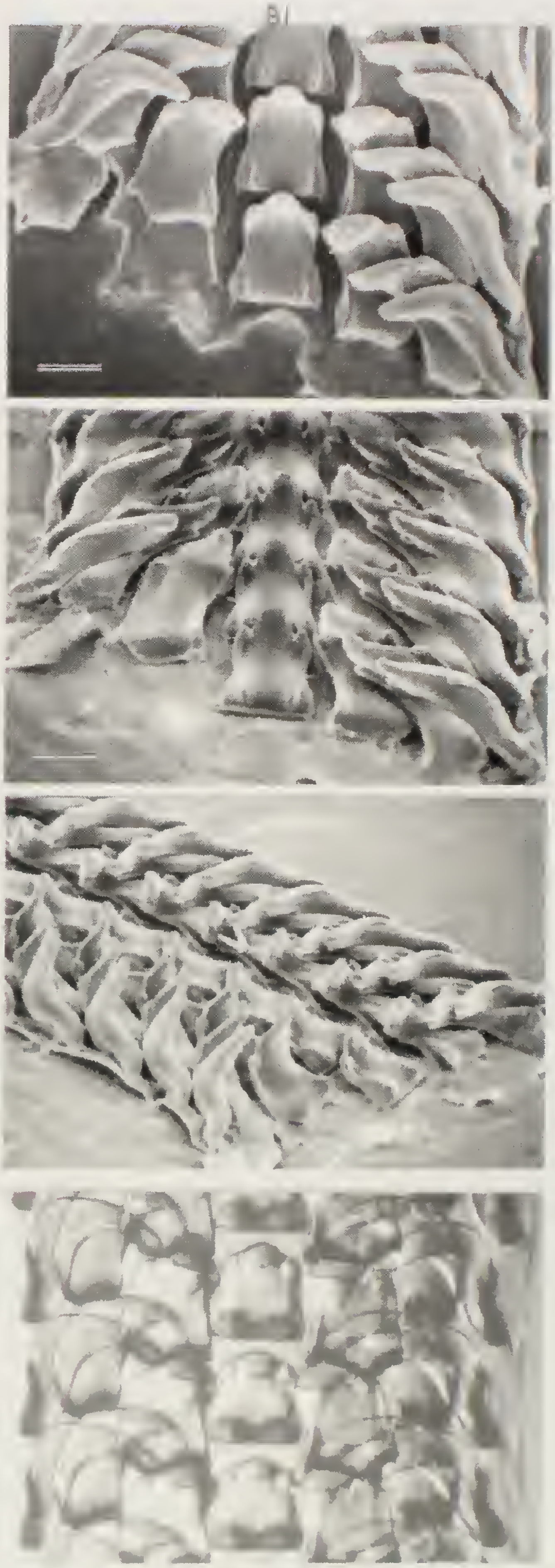


Figure 155. *Barycypraea fultoni*

203

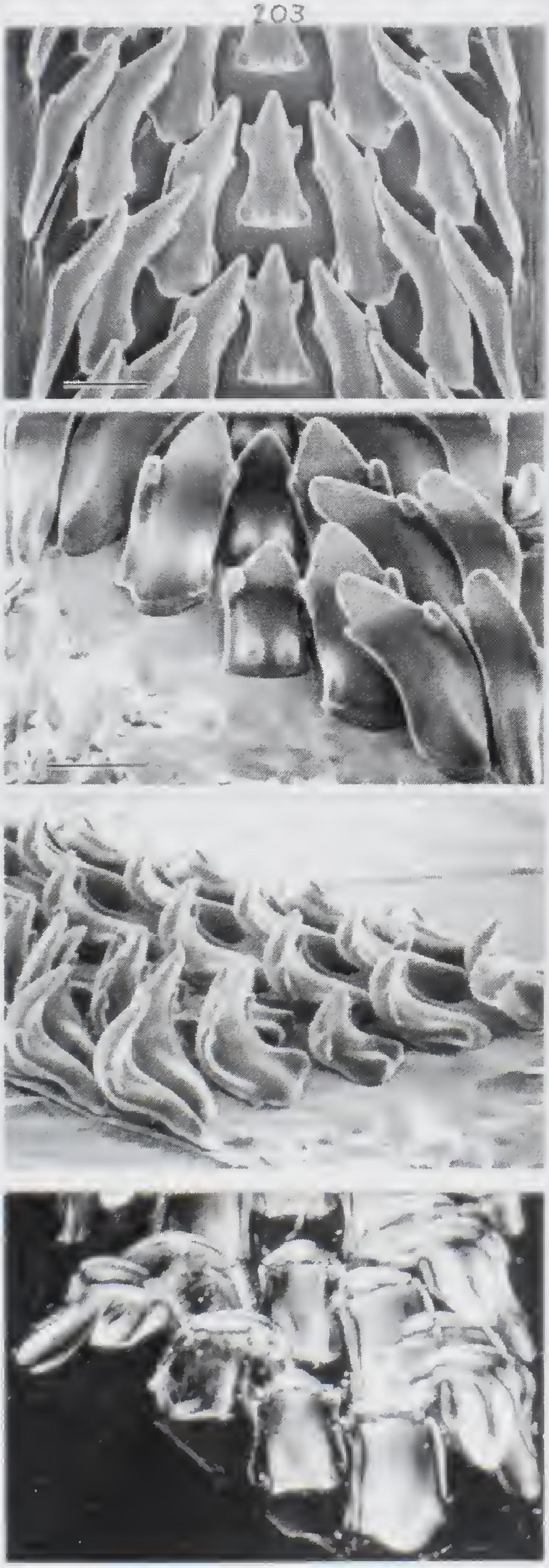


Figure 156. *Barycypraea teulerei*

4

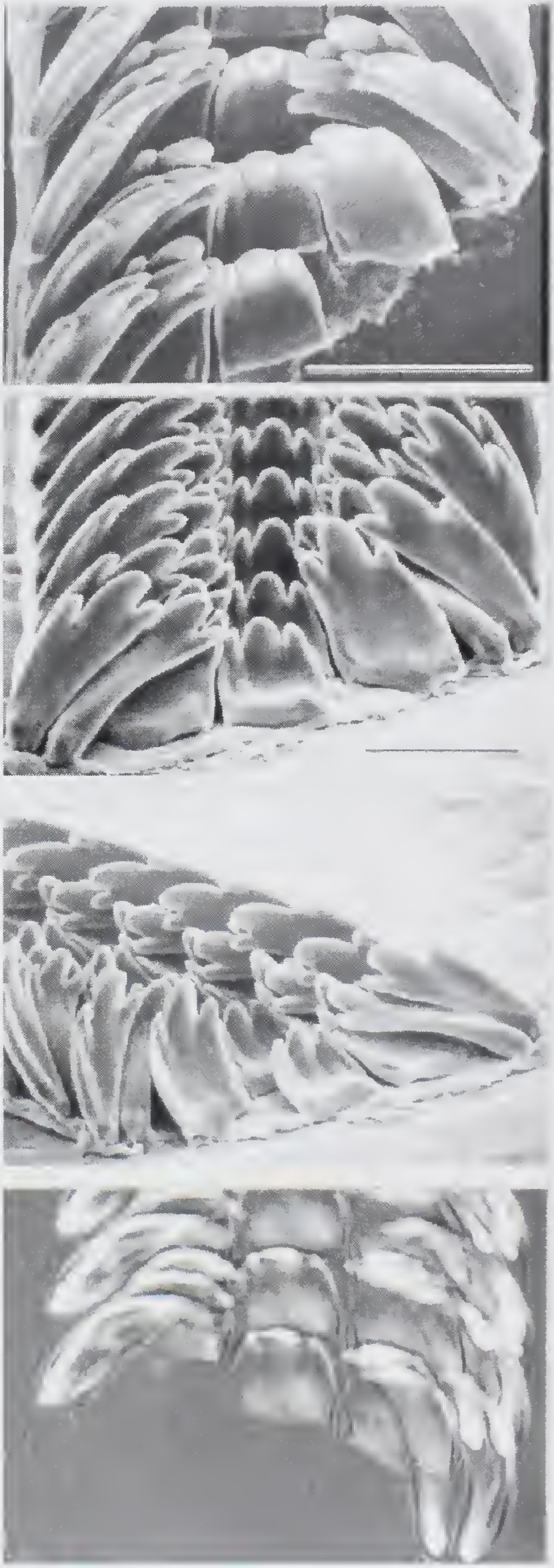


Figure 157. *Cypraeovula alfredensis*

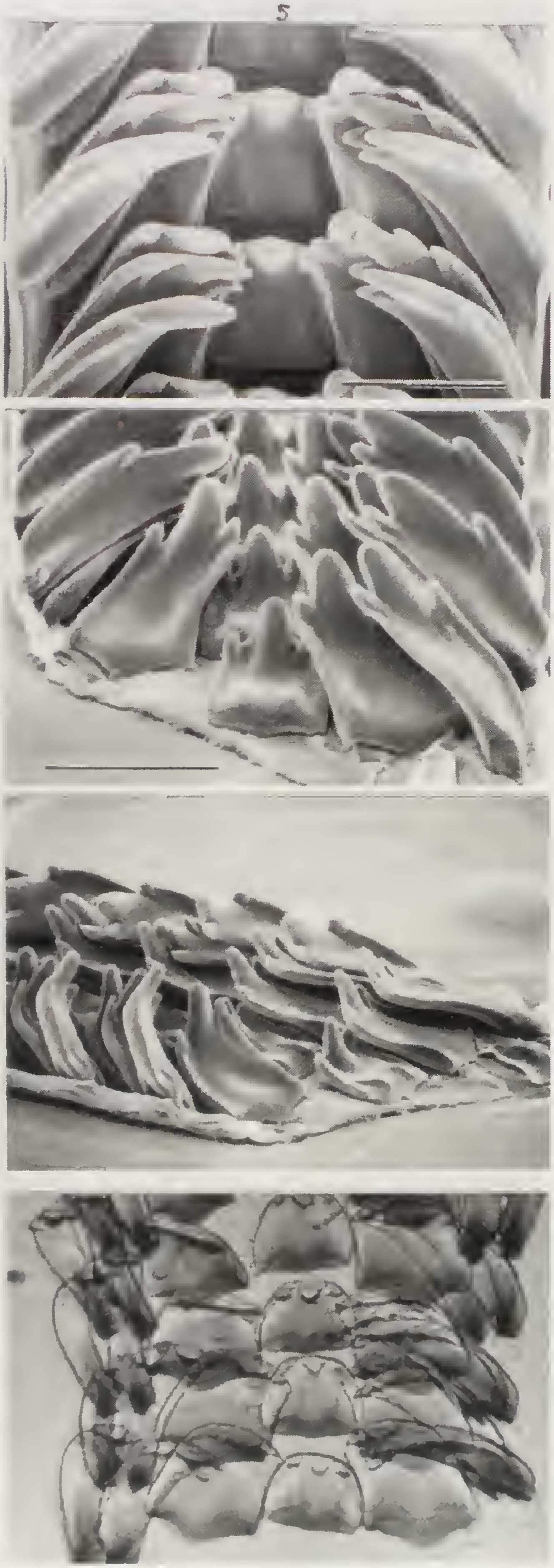


Figure 158. *Cypraeovula algoensis*

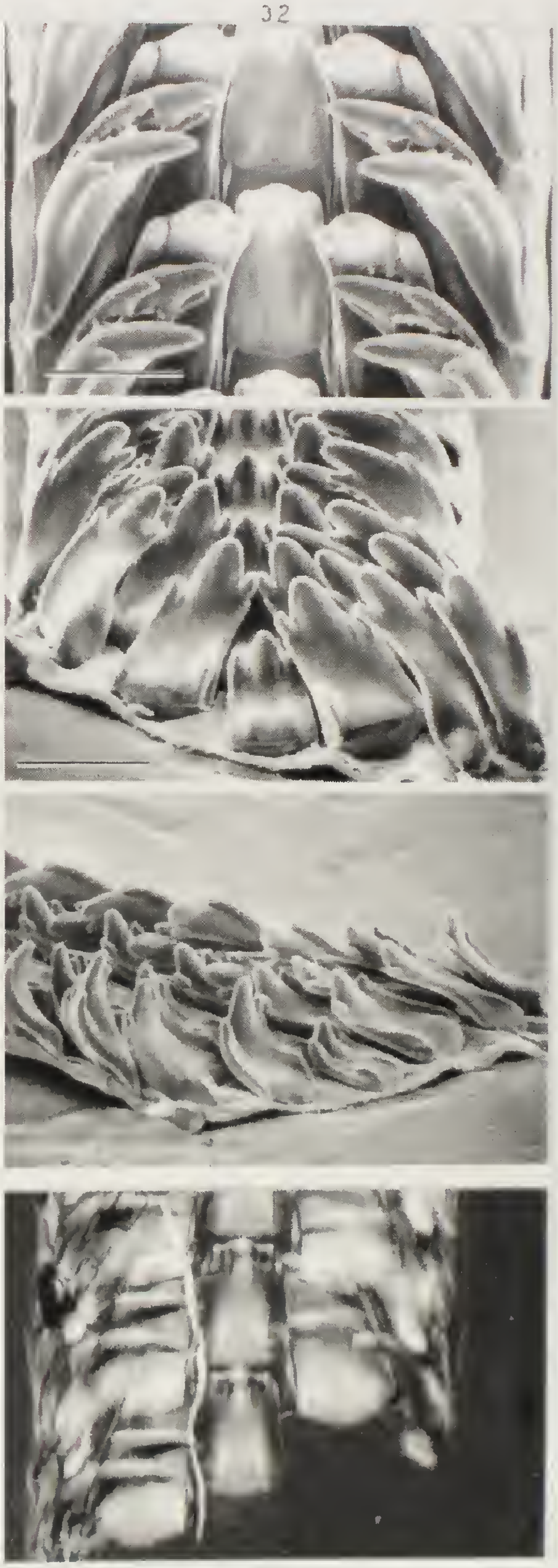


Figure 159. *Cypraeovula capensis*

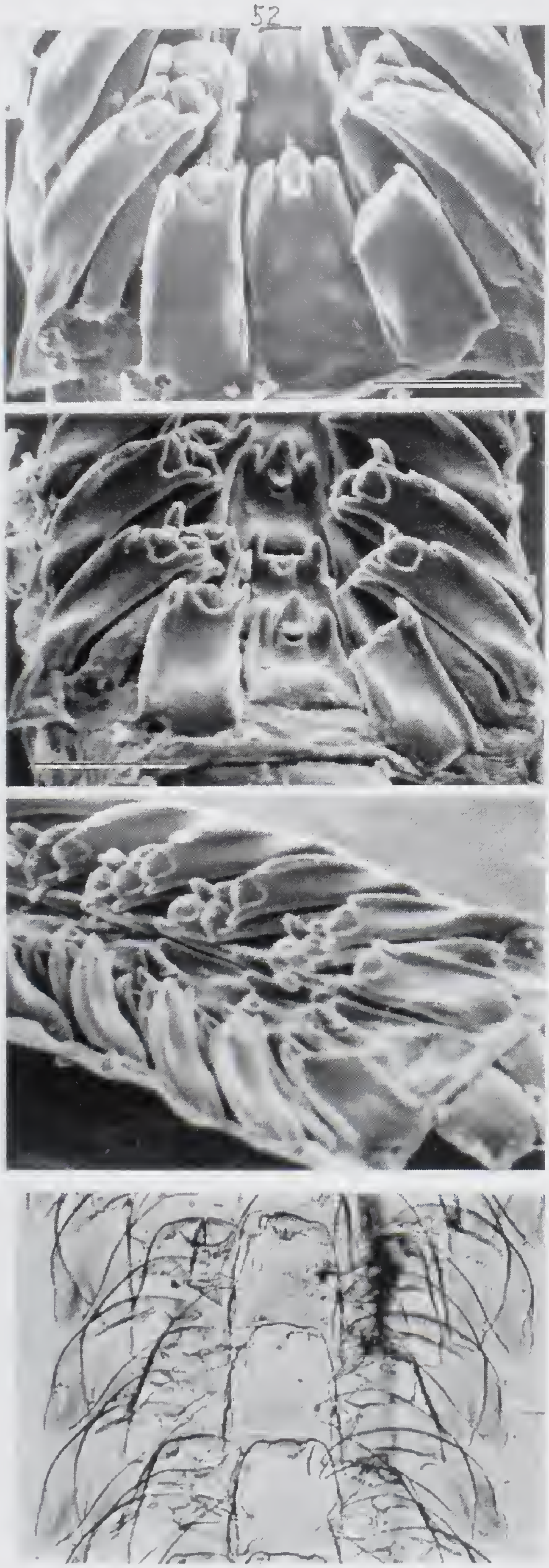


Figure 160. *Cypraeovula connelli*

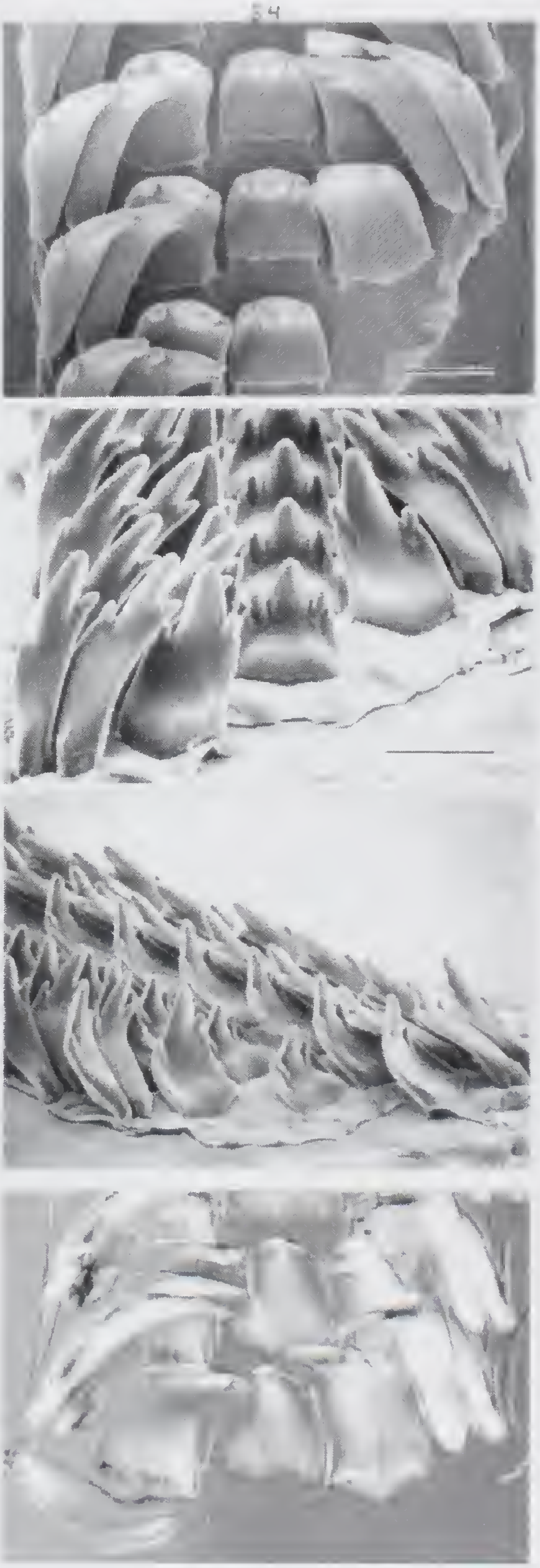


Figure 161. *Cypraeovula coronata*

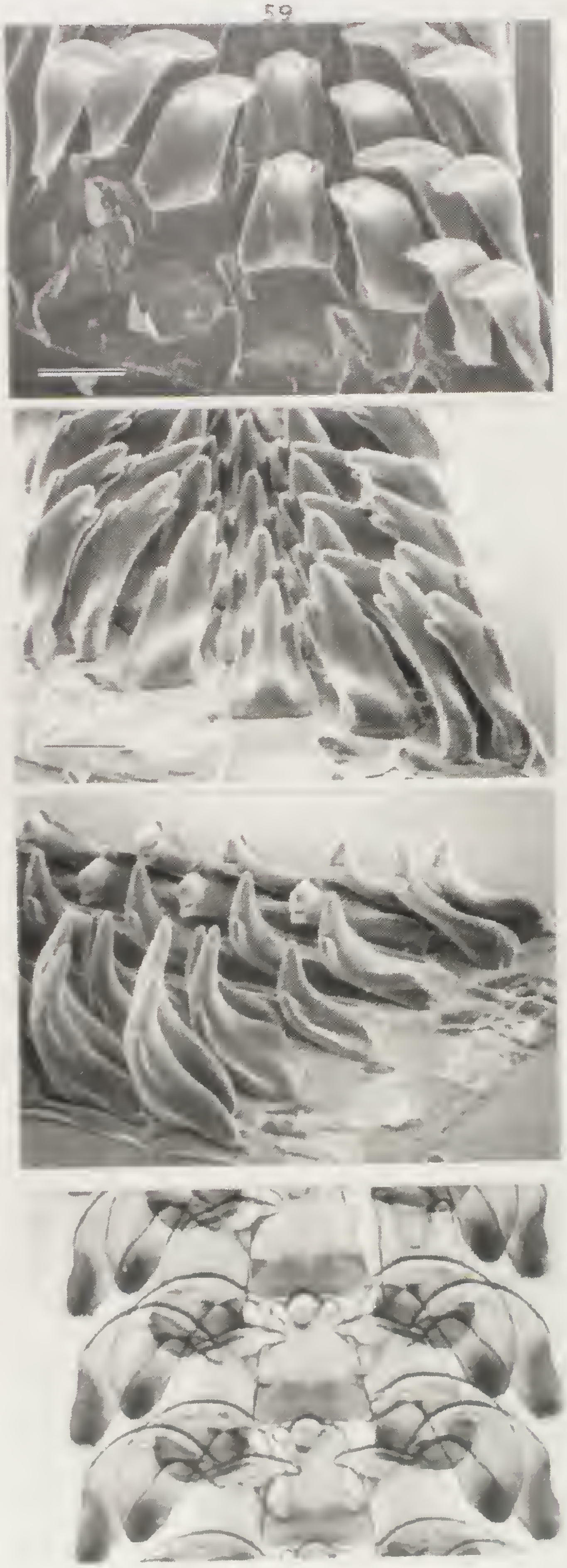


Figure 162. *Cypraeovula cruickshanki*

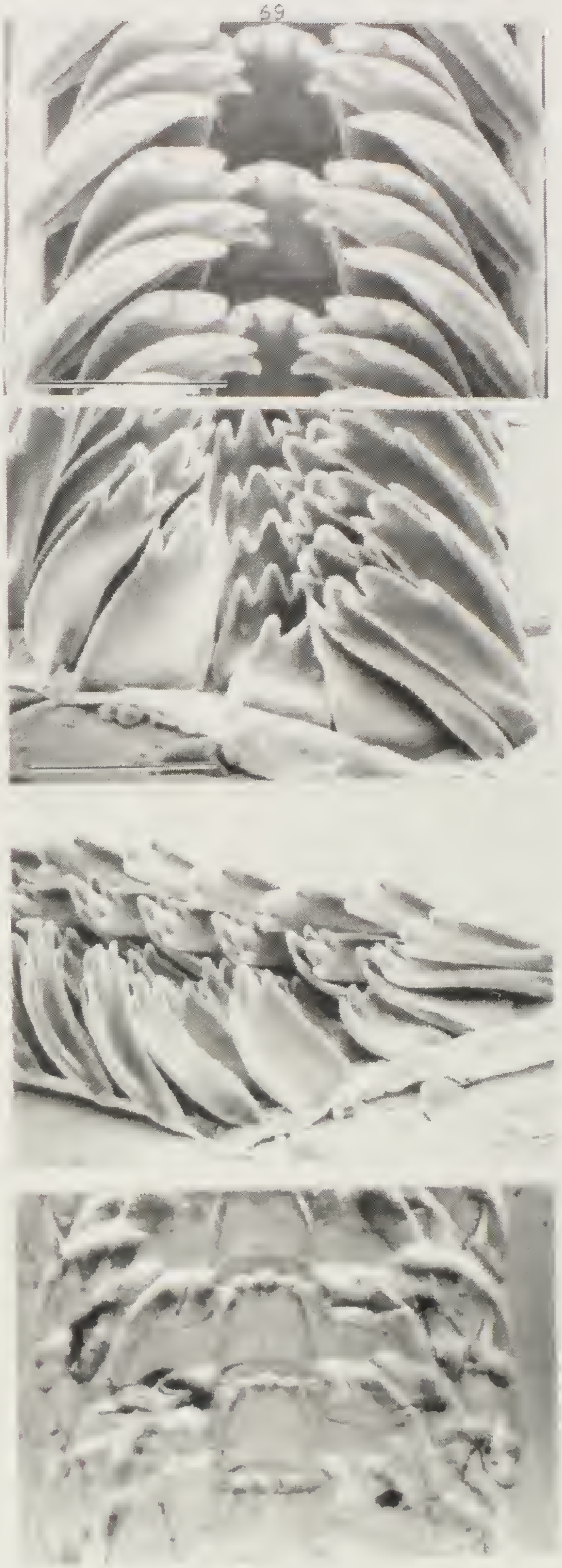


Figure 163. *Cypraeovula edentula*

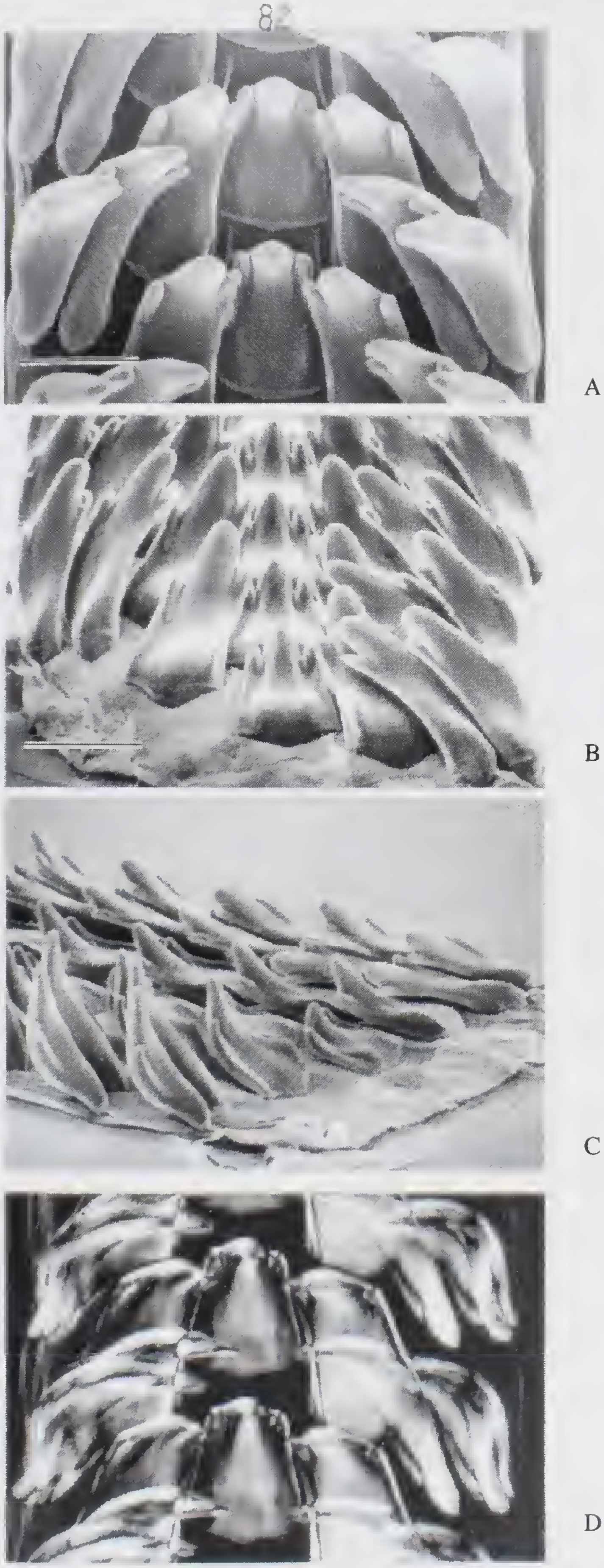


Figure 164. *Cypraeovula fuscodentata*

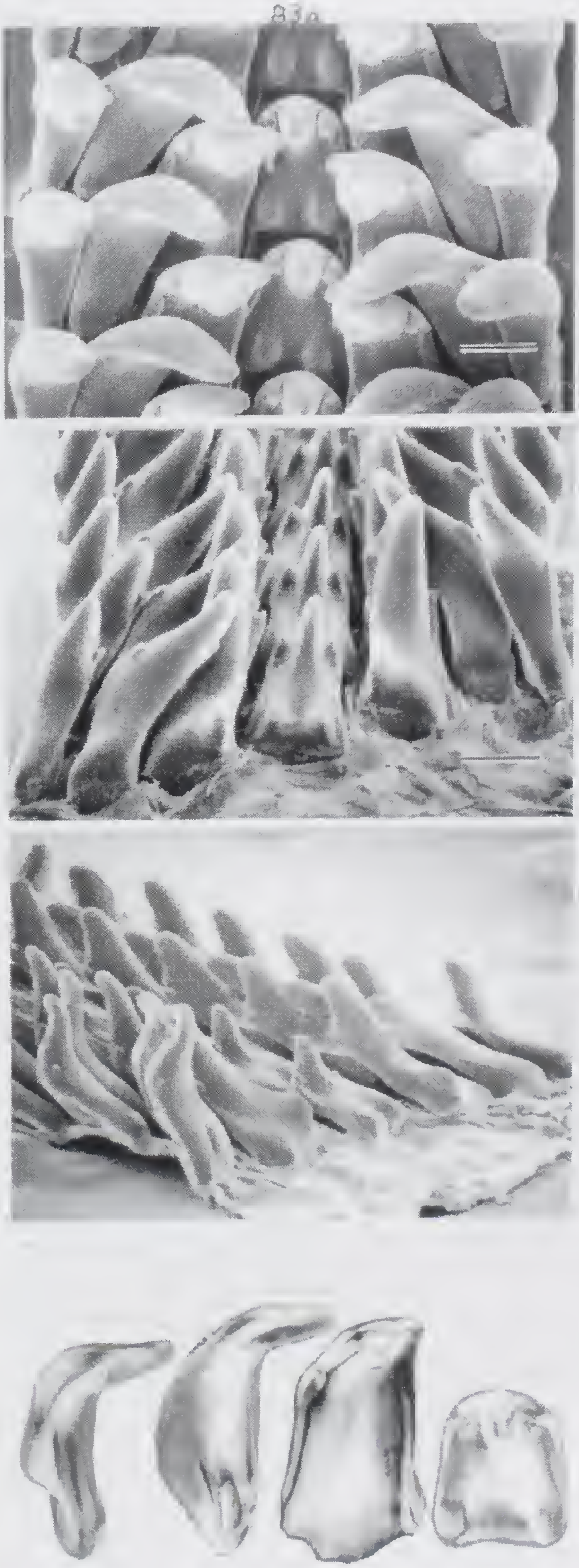


Figure 165. *Cypraeovula fuscorubra*

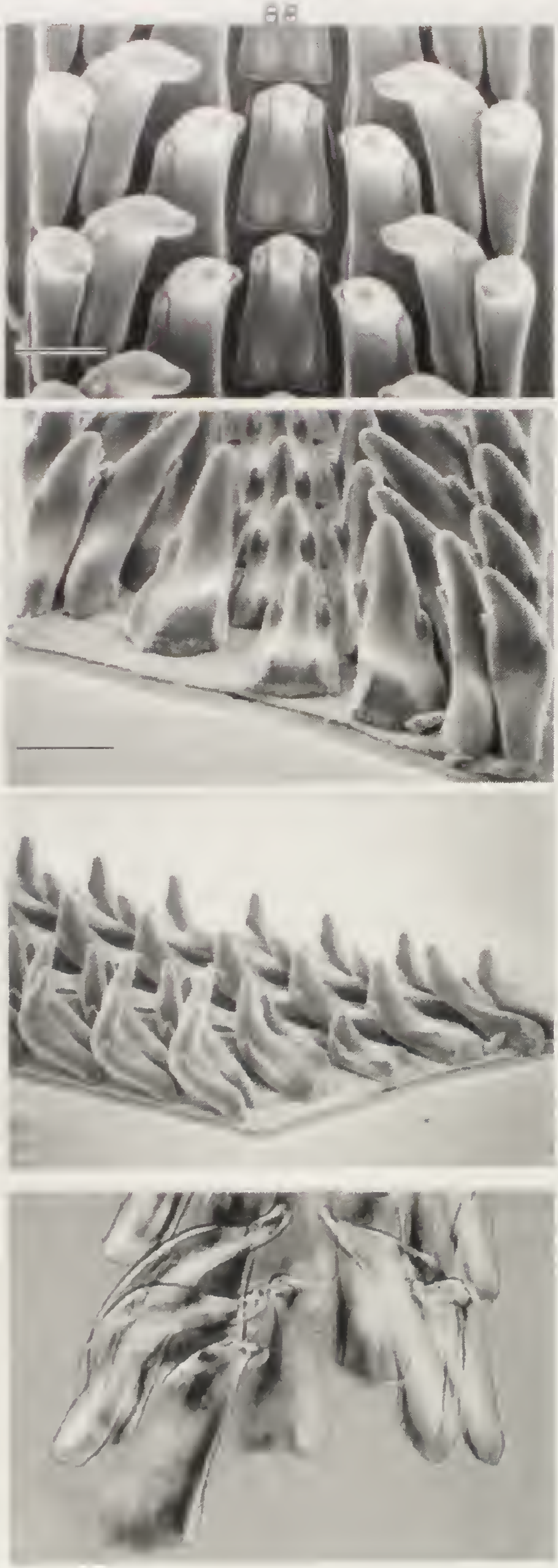


Figure 166. *Cypraeovula gondwanalandensis*

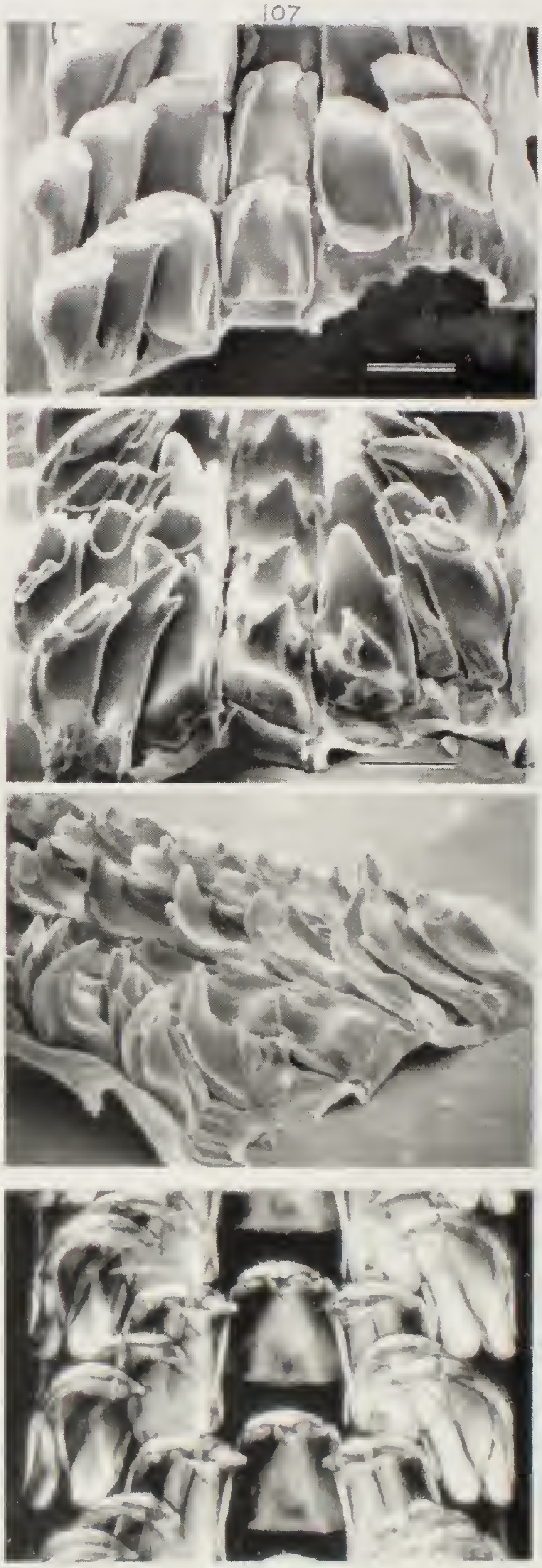


Figure 167. *Cypraeovula iutsui*

141

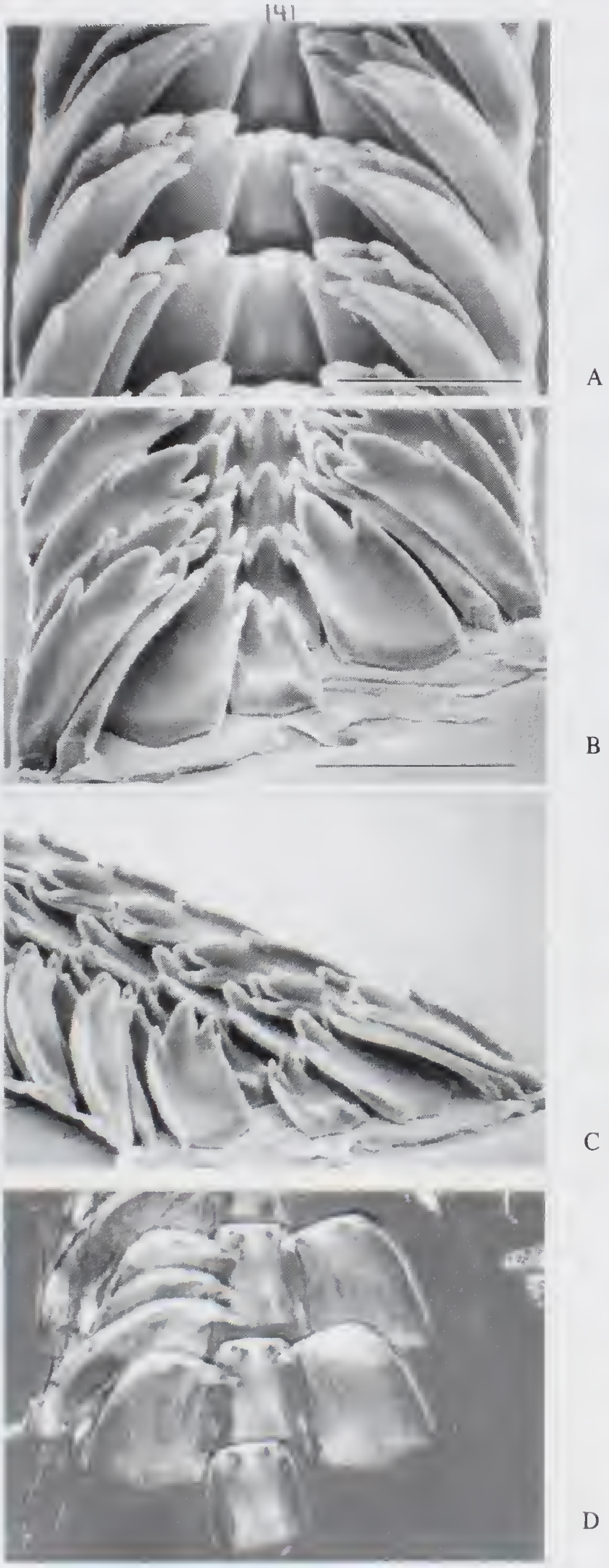


Figure 168. *Cypraeovula mikeharti*

98

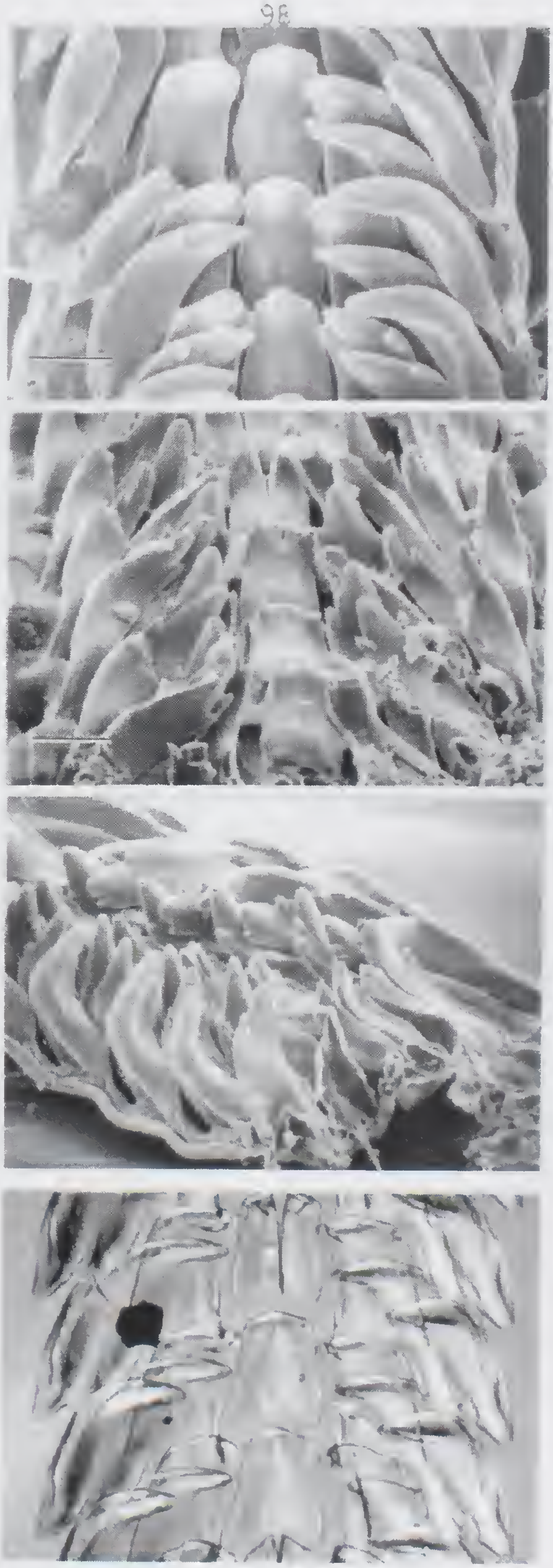


Figure 169. *Nesiocypraea hirasei*

116

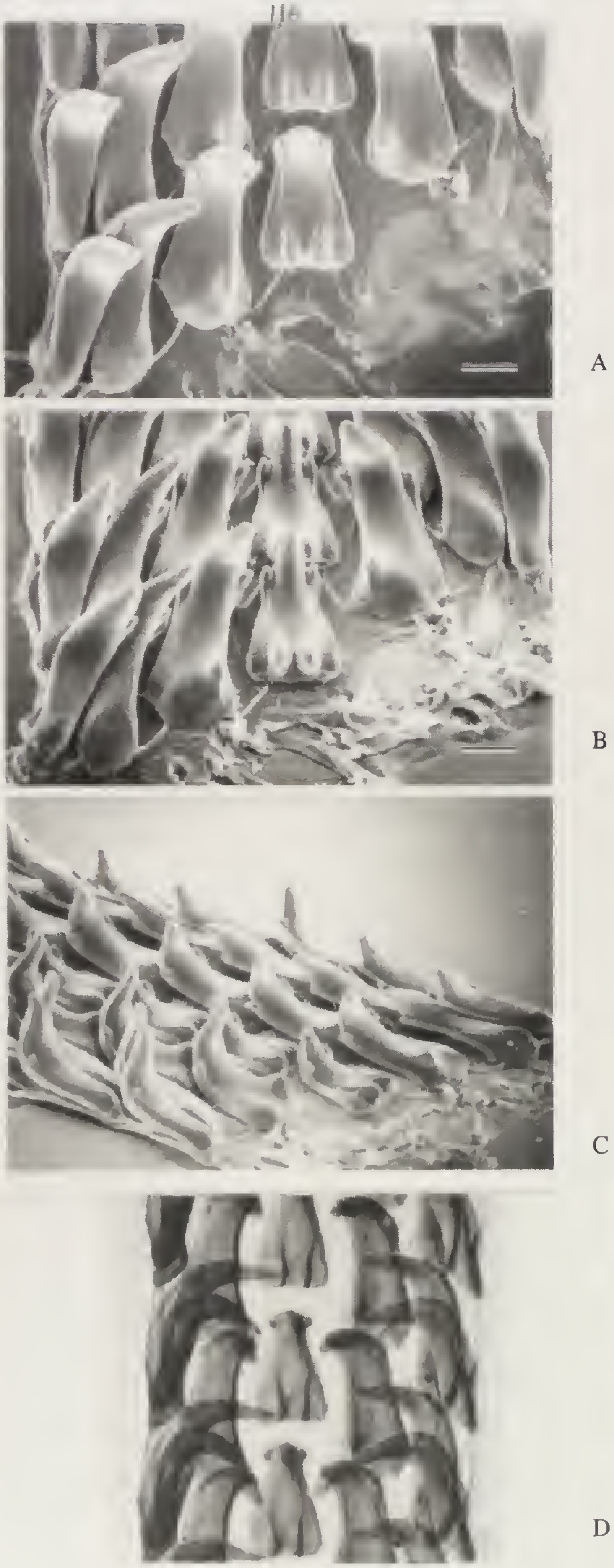


Figure 170. *Nesiocypraea langfordi*

140

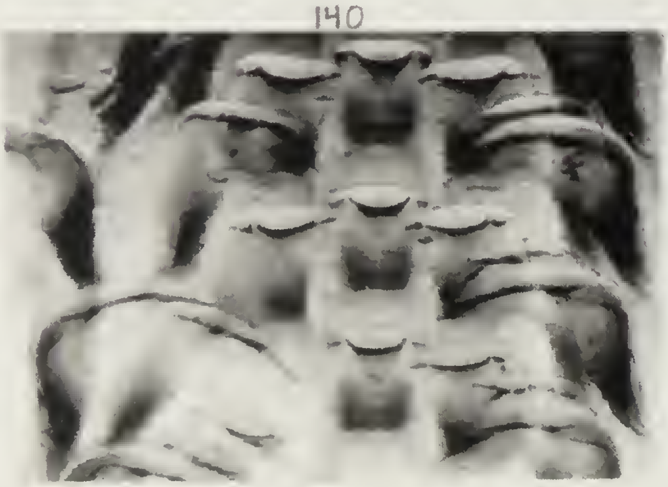


Figure 171. *Nesiocypraea midwayensis*

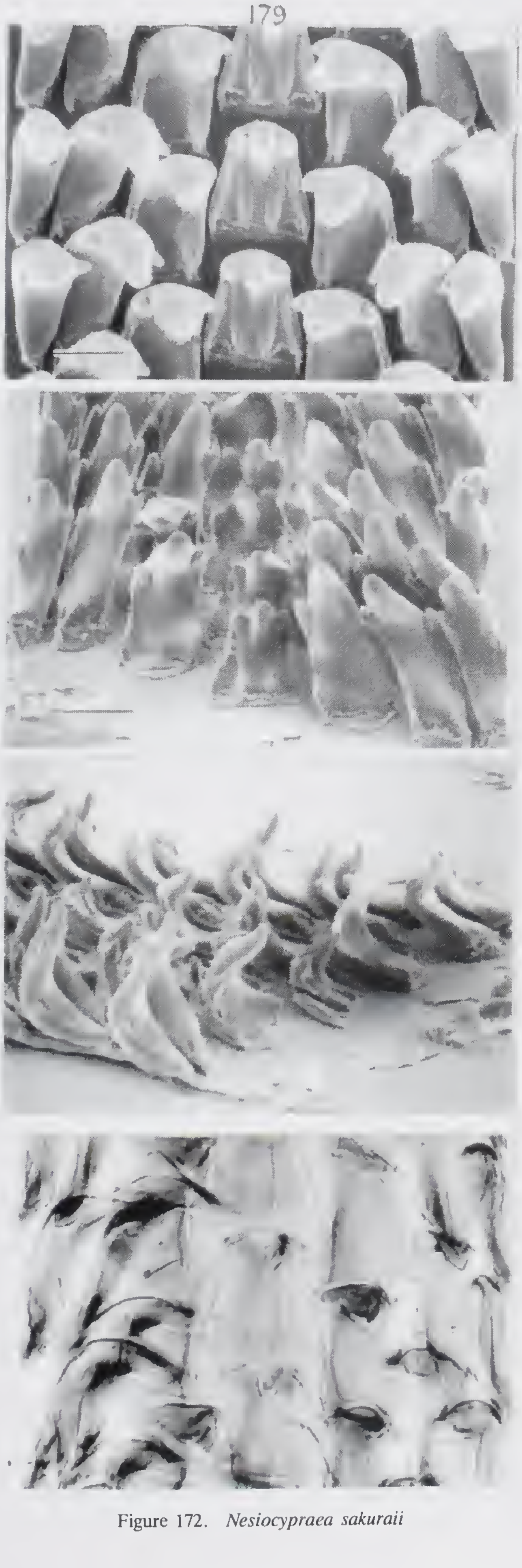


Figure 172. *Nesiocypraea sakuraii*

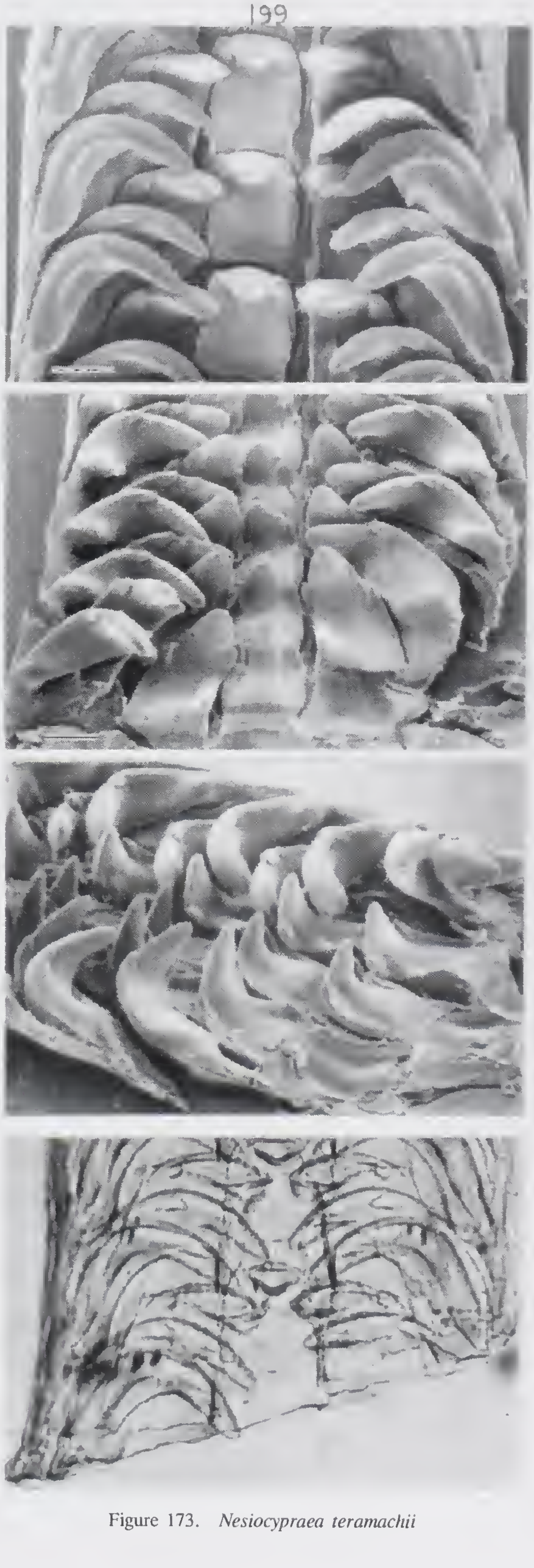
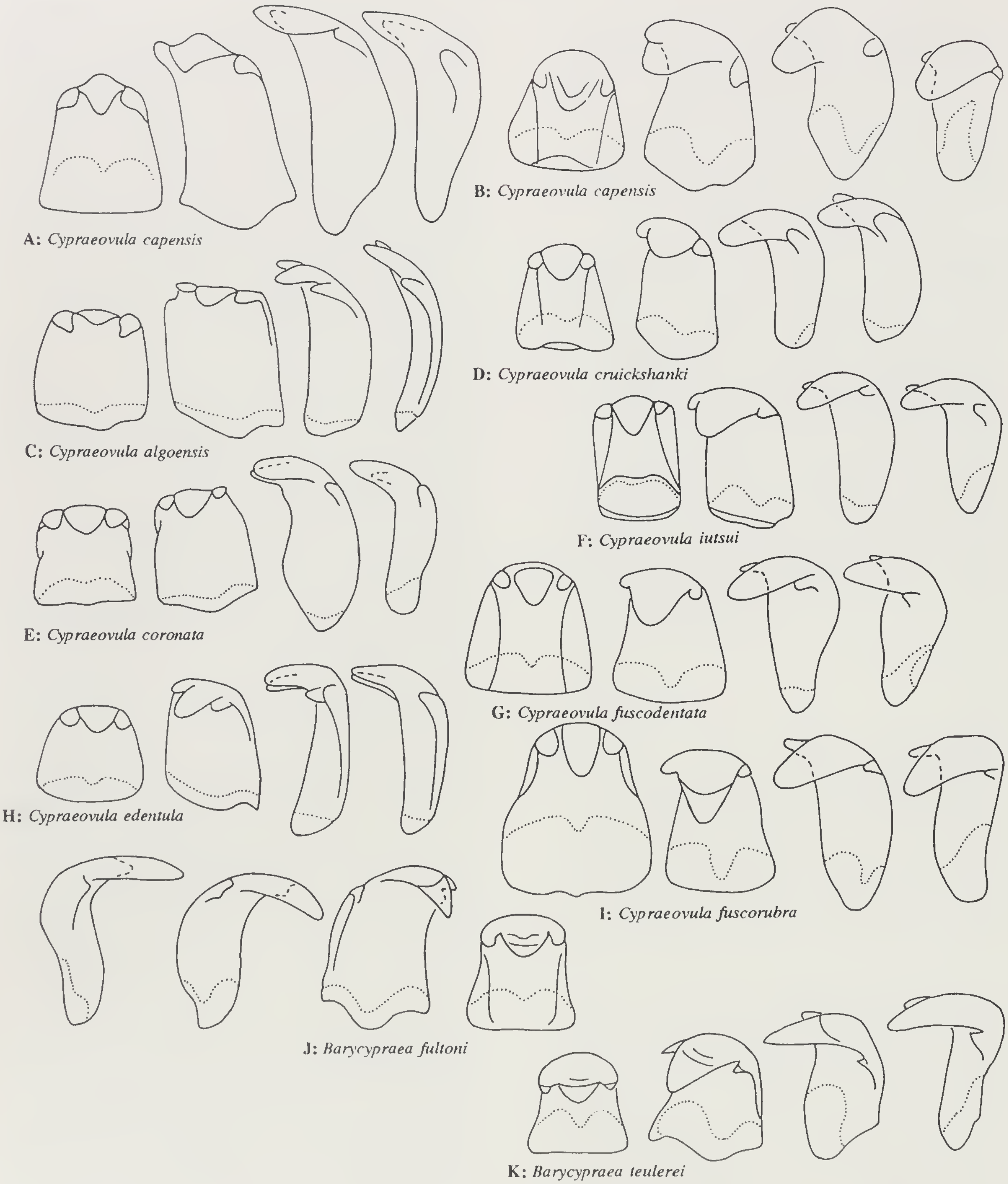


Figure 173. *Nesiocypraea teramachii*



A: *Cypraeovula capensis*

B: *Cypraeovula capensis*

C: *Cypraeovula algoensis*

D: *Cypraeovula cruickshanki*

E: *Cypraeovula coronata*

F: *Cypraeovula iutsui*

G: *Cypraeovula fuscodentata*

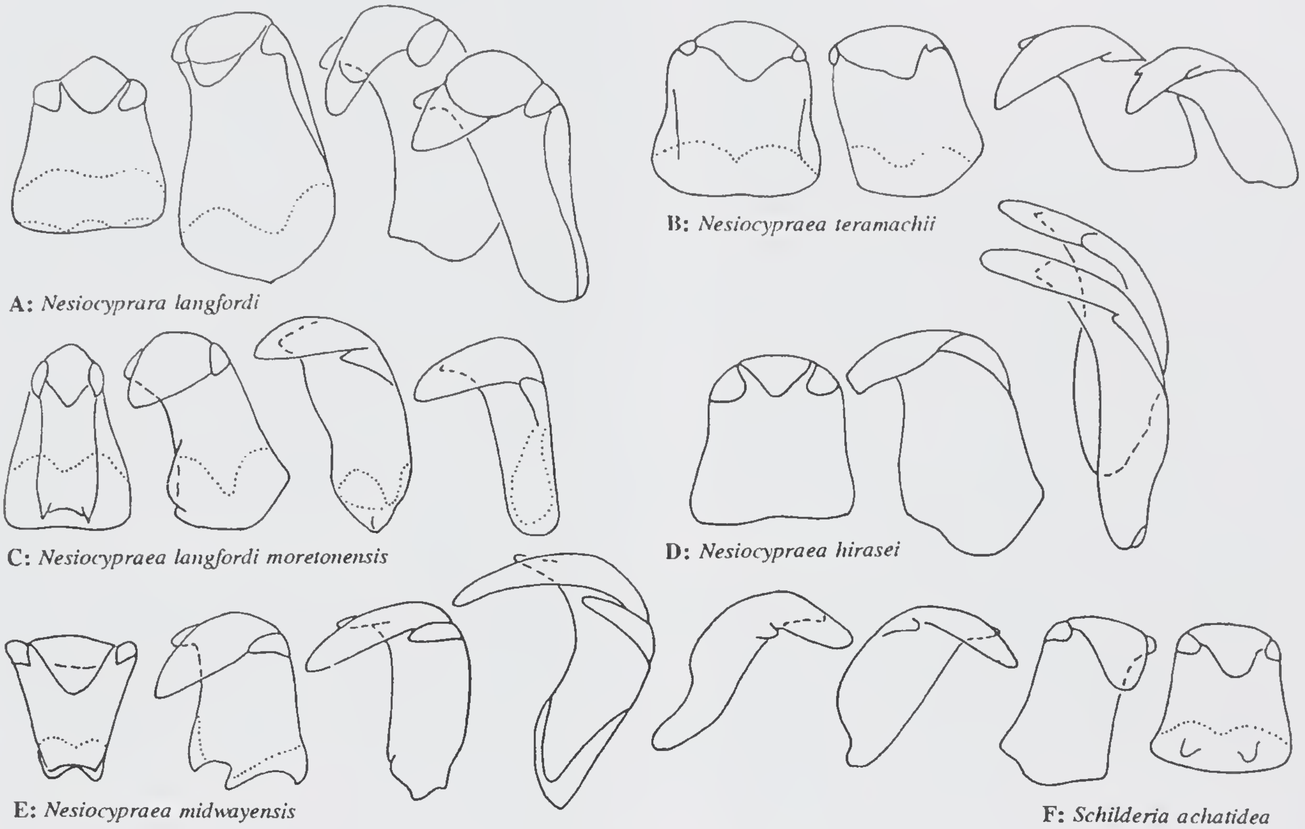
H: *Cypraeovula edentula*

I: *Cypraeovula fuscorubra*

J: *Barycypraea fultoni*

K: *Barycypraea teulerei*

Figure 174. Achatidea pattern drawings I



A: *Nesiocyprara langfordi*

B: *Nesiocypraea teramachii*

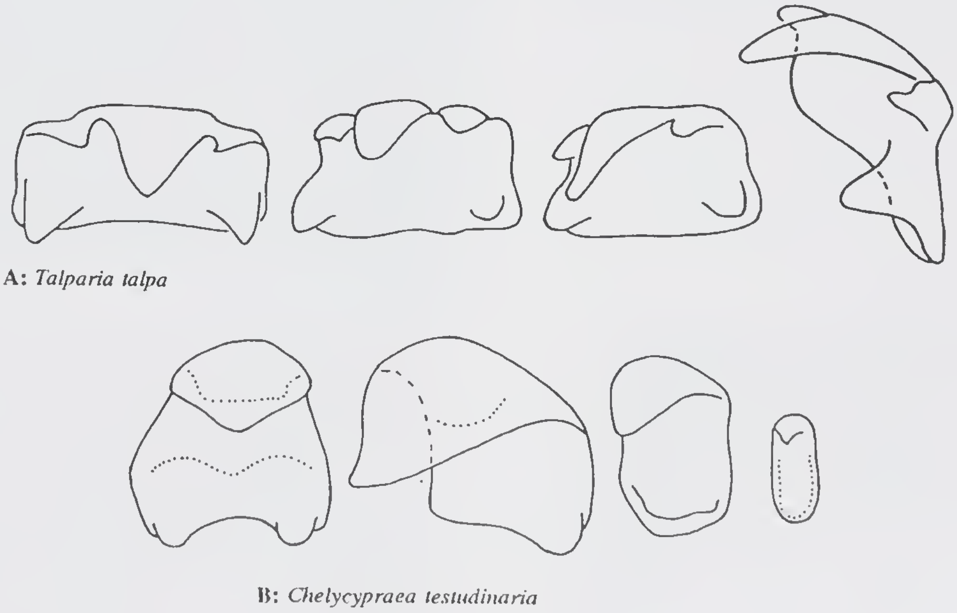
C: *Nesiocypraea langfordi moretonensis*

D: *Nesiocypraea hirasei*

E: *Nesiocypraea midwayensis*

F: *Schilderia achatidea*

Figure 175. Achatidea pattern drawings II



A: *Talparia talpa*

B: *Chelycypraea testudinaria*

Figure 181. Talpa & Testudinaria pattern drawings

The Talpa Pattern (Figures 176, 177, 178, 181).
Model Species: *Talparia talpa* (Linnaeus, 1758).

Species: *Talparia exusta* (Sowerby, 1832); *T. talpa* (Linnaeus, 1758).

The radular teeth in *T. exusta* and *T. talpa* are, as in the isabella pattern, precisely arranged in rows, each tooth noticeably separate from the others, but all the teeth are wider than they are long (length/width 0.89; n=3). The central tooth (110x115 microns to 150x205 microns; n=3) is relatively small for the size of the shell, and about the same size as are the other teeth. The teeth are tricuspid, with prominent basal denticles. Most of the teeth bear a dark-staining internal bract. There are 225 to 385 radular rows (n=3), and 9.6 to 17.6 rows of teeth per mm of radula. Figure 177 illustrates how markedly the marginal teeth of this pattern differ from those of all other cowries.

In his description of the subgenus *Talparia*, Troschel (1863) mentioned the prominence of the central tooth and the well developed marginal teeth, and he listed *Talparia* first among the subgenera of *Cypraea* because of the "integrity" of the radular teeth. The shells bear a large, shallow, ridged fossula. The mantle in both species is dark black or green-black but there are large, fleshy papillae only in *T. talpa*. There is a bursa copulatrix in the female. *T. talpa* occurs throughout the Indo-West Pacific; *T. exusta* is endemic to the Red Sea and the Gulf of Aden. *Talparia* fossils are known from the Plio-Pleistocene of Guam.

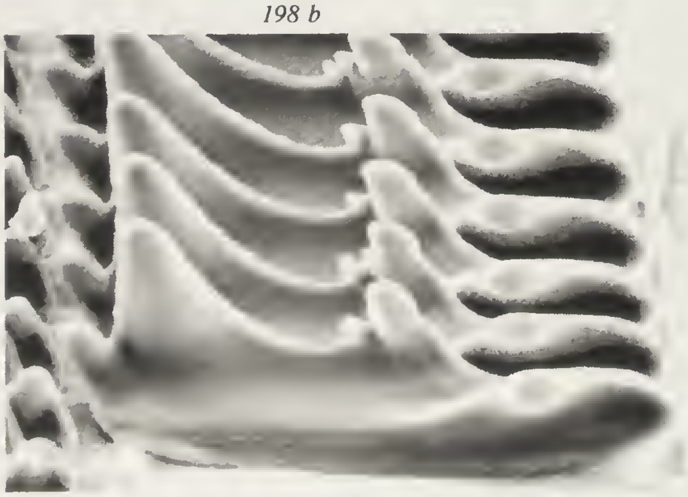


Figure 176. *Talparia talpa* marginal teeth

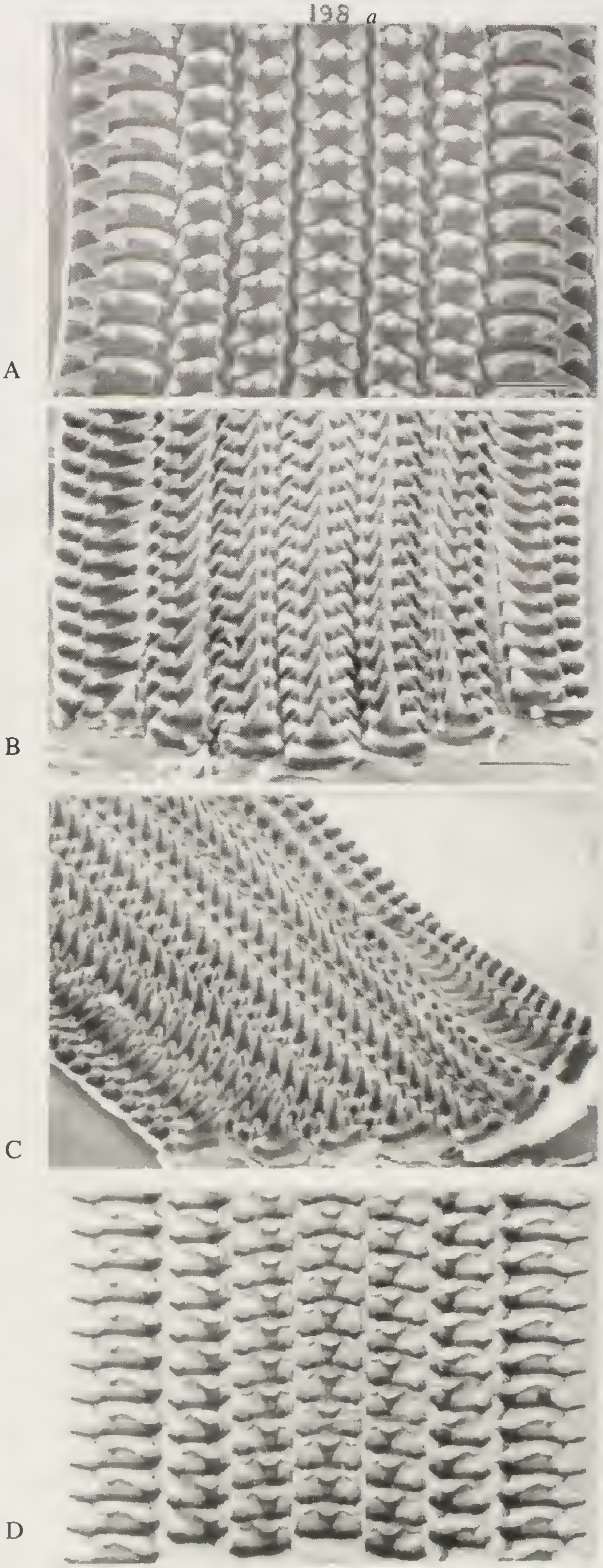


Figure 177. *Talparia talpa*

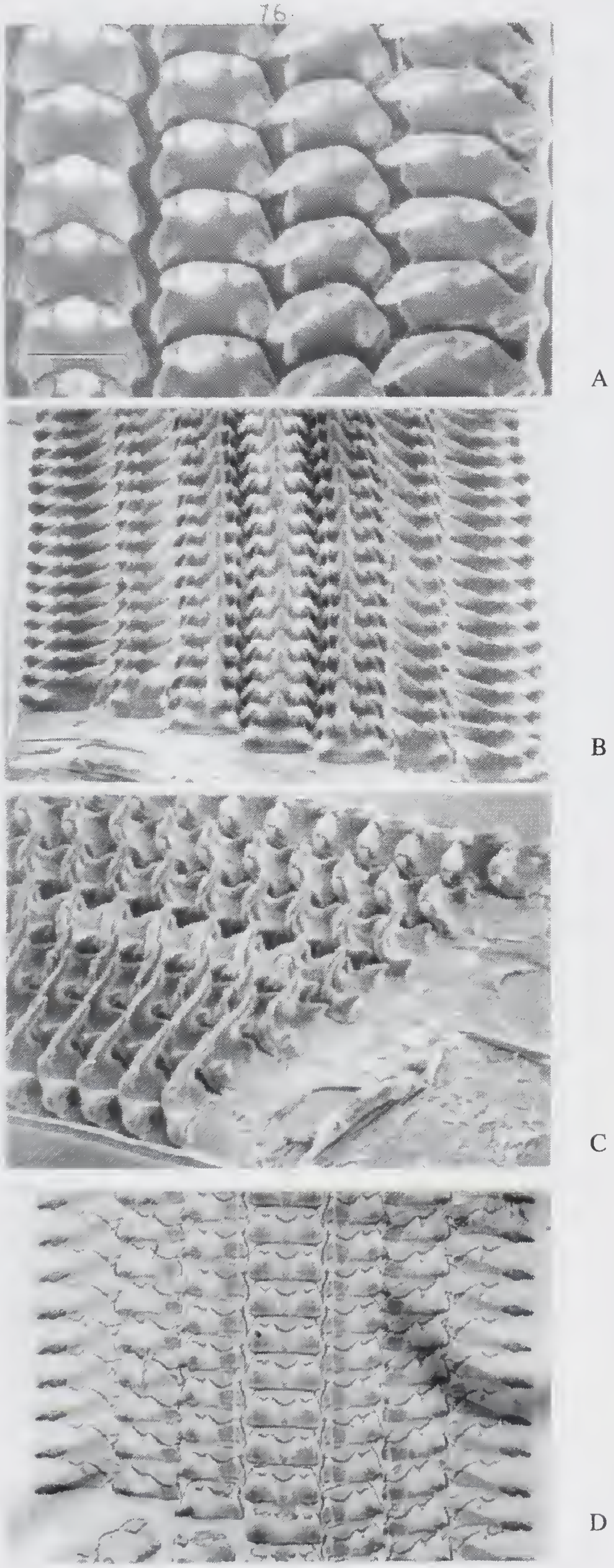


Figure 178. *Talparia exusta*

The Testudinaria Pattern. (Figures 179, 180, 181).
Model species (and only species in the genus):
Chelycypraea testudinaria (Linnaeus, 1758).

The radular teeth are distinguished by the almost vestigial, unicuspid outer marginal teeth (less than 200 microns length) which nestle against the inner marginals (mean length 460 microns). Figure 180 shows the relative sizes of marginal, submarginal and lateral teeth. The teeth are more closely spaced than in *Talparia*, the lateral slightly overlapping the central tooth. The laterals are the longest teeth in the radular row (mean length 700 microns), with two basal denticles, one on each corner of the basal platform, and reduced lateral cusps on either side of the central cusp. The central tooth is longer than it is wide (mean dimensions 580x365 microns, l/w ratio = 1.6), flares at the basal corners, has reduced lateral cusps as in the lateral teeth, and lacks both denticles and an internal bract. There are 140 rows of teeth (n=1), with 2.7 rows per mm of radula (n=1).

The shell of *C. testudinaria* is massive, cylindrical, and bears a large, shallow, prominently ridged fossula. The mantle is dark brown with elongate, tentacular papillae. The bursa copulatrix is present in females. A fossil record has not been reported.

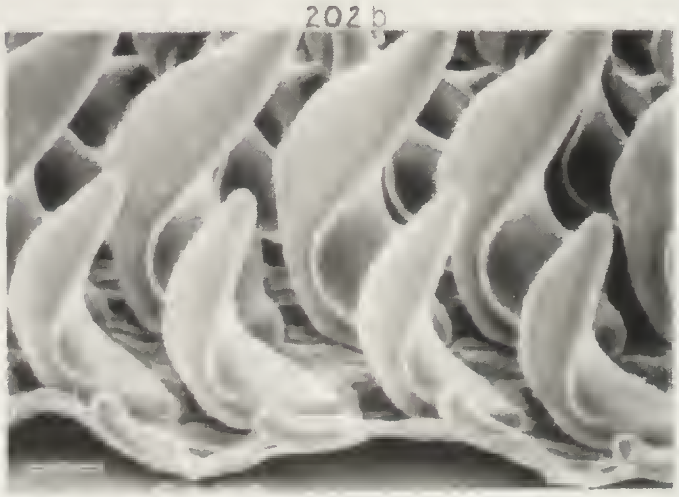


Figure 179. *Chelycypraea testudinaria*

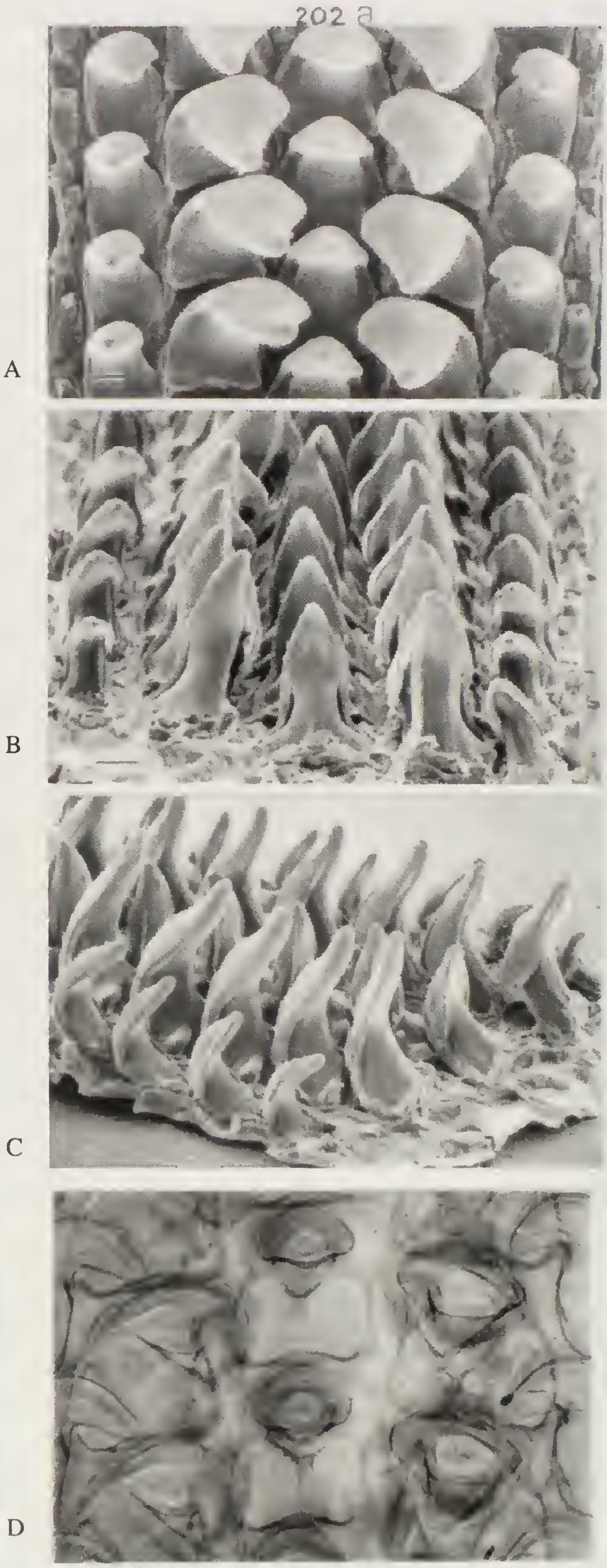


Figure 180. *Chelycypraea testudinaria*

The Limacina Pattern (Figures 182 -195).
Model species: *Staphylaea limacina* (Lamarck, 1810).

Species: *Blasicrura goodallii* (Sowerby, 1832); *B. pallidula* (Gaskoin, 1849); *B. summersi* (Schilder, 1958); *Nucleolaria cassiaui* (Burgess, 1965); *N. granulata* (Pease, 1862); *N. nucleus* (Linnaeus, 1758); *Palmadusta yaloka* Steadman & Cotton, 1943; *Staphylaea limacina* (Lamarck, 1810); *S. semiplota* (Mighels, 1845); *S. staphylaea* (Linnaeus, 1758).

In this group of cowries, the teeth resemble those of the erosa pattern with internal and subtending bracts, but the central tooth bears five cusps rather than three. The central tooth varies in size and shape: except in *N. cassiaui*, *N. granulata*, and *S. semiplota*, it is less than 100 microns long (mean dimensions 95x86 microns (n=3) in *Nucleolaria*; 72x105 microns (n=5) in *Staphylaea*; 51x48 microns (n=5) in *Blasicrura* and *Palmadusta*). It is wider than it is long in *Nucleolaria* (l/w ratio 0.97) and *Staphylaea* (l/w ratio 0.7), and about as long as it is wide in *Blasicrura* and *Palmadusta* (l/w ratio 1.05). The lateral tooth is conspicuously larger than the central; the lateral and marginals overlap one another, and each bears four cusps. The marginals are slender, transparent with OM, bladelike in profile in *Nucleolaria*, and long, curving over the lateral and nested in the folded position with the outer marginal across the inner marginal in *Blasicrura, Palmadusta* and *Staphylaea*. Figures 193 and 194 show two specimens of *S. staphylaea* with different tooth forms.

Central tooth dimensions: 40x40 to 60x50 microns (n=5) in *Blasicrura* and *Palmadusta*; 50x60 to 225x150 microns (n=3) in *Nucleolaria*; and 55x80 to 110x145 microns (n=5) in *Staphylaea*.
No. of radular rows: 60 to 100 (n=3) in *Blasicrura* and *Palmadusta*; 165 to 180 (n=2) in *Nucleolaria*.
No. of radular rows per mm radula: 14.6 to 40 (n=4) in *Blasicrura* and *Palmadusta*; 9.3 to 19.5 (n=3) in *Nucleolaria*; 2.8 to 16.8 (n=5) in *Staphylaea*.

This pattern is identified with a diverse group of species, all found in the Indo-West Pacific. Species in *Nucleolaria* and *Staphylaea* tend to have granular shells, and brown to black mantles with elongate papillae. Mantles in *B. pallidula* and *B. summersi* are dark, with short, fleshy papillae; in *B. goodallii* the mantle is white with minute papillae; in *P. yaloka* the mantle is crimson. A bursa copulatrix is present in *B. goodallii* but not in *Nucleolaria* and *Staphylaea*. Larval shells are like those of *Erosaria*. Fossils of *Blasicrura* and *Palmadusta* are known from the Pliocene and Pleistocene respectively of Indonesia; *Nucleolaria* from the middle/late Eocene of Washington; and *Staphylaea* from the Oligocene of Pakistan.

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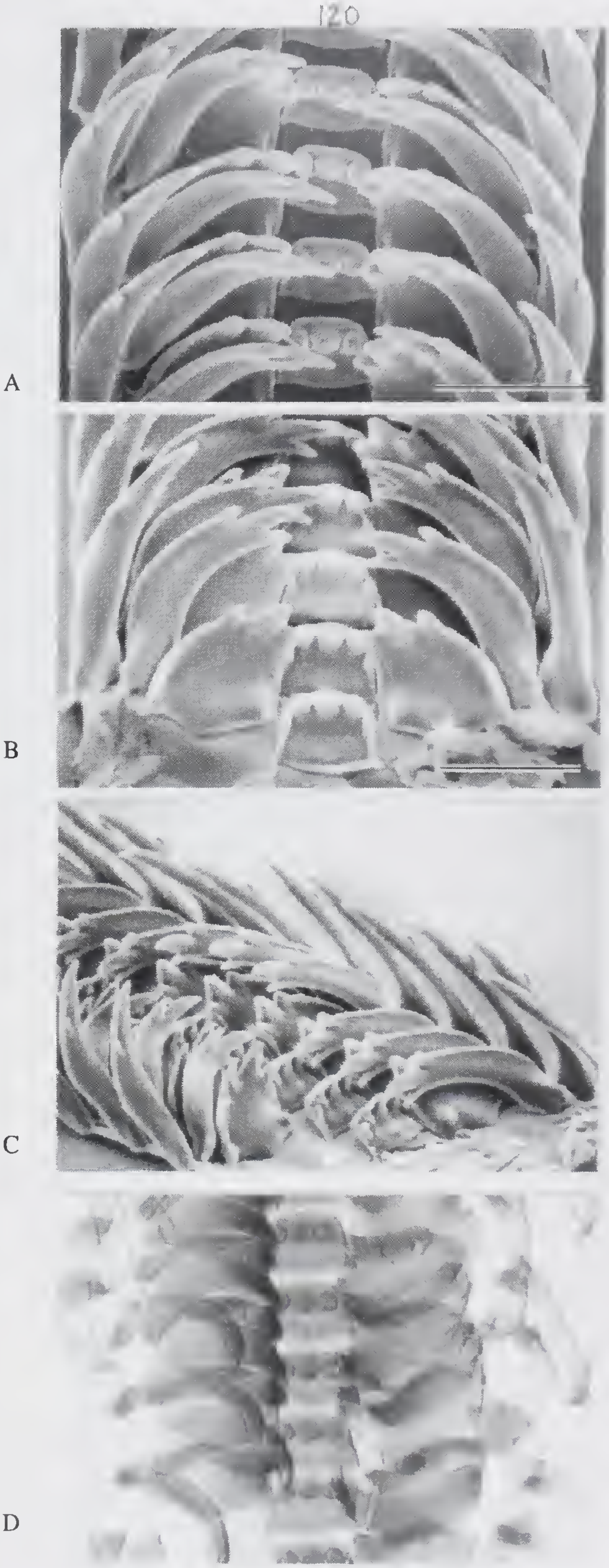


Figure 182. *Staphylaea limacina*

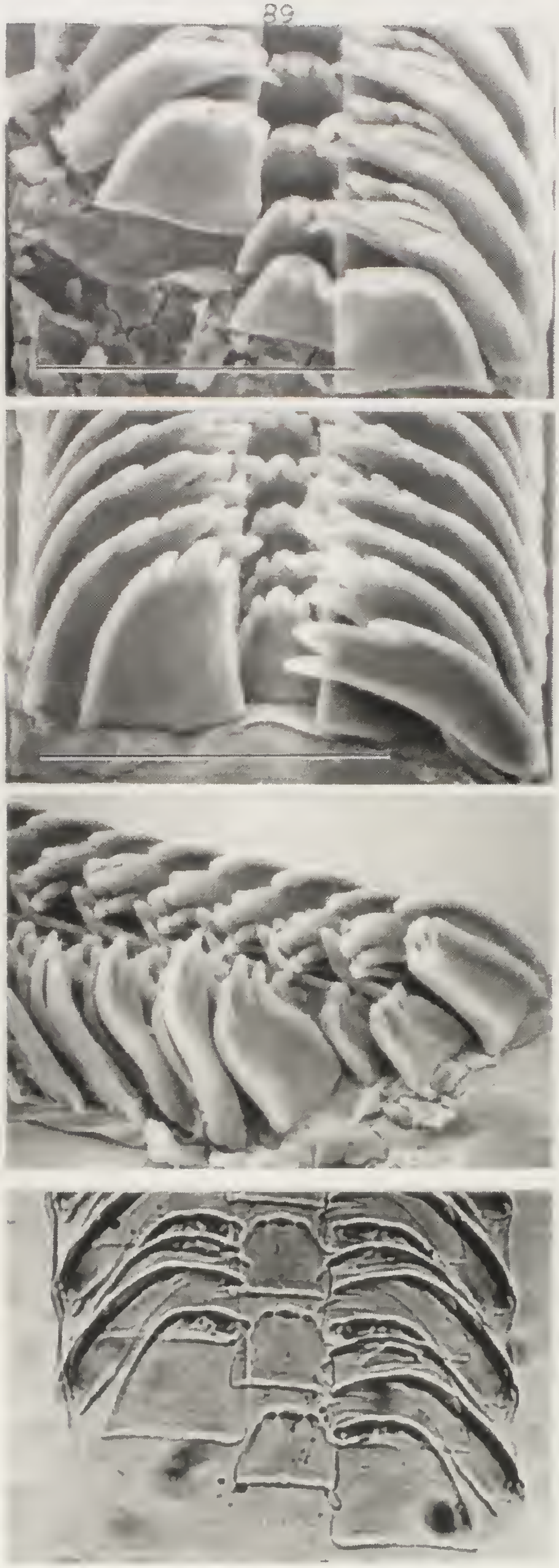


Figure 183. *Blasicrura goodallii*

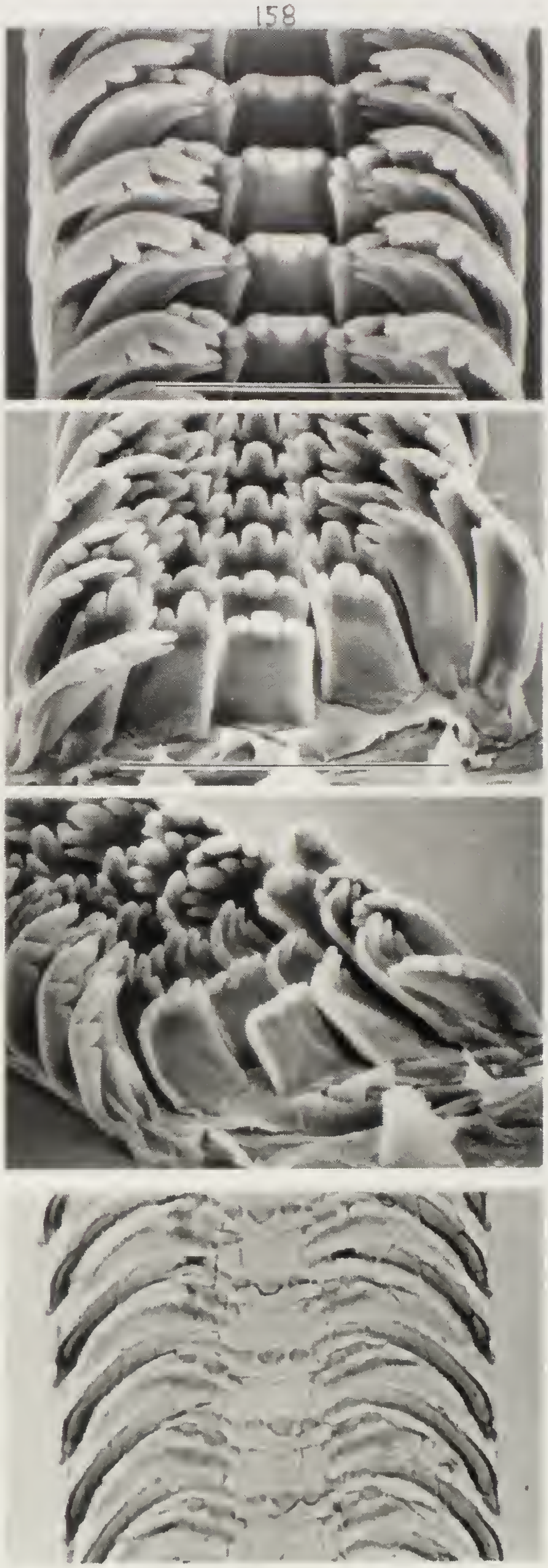


Figure 184. *Blasicrura pallidula*

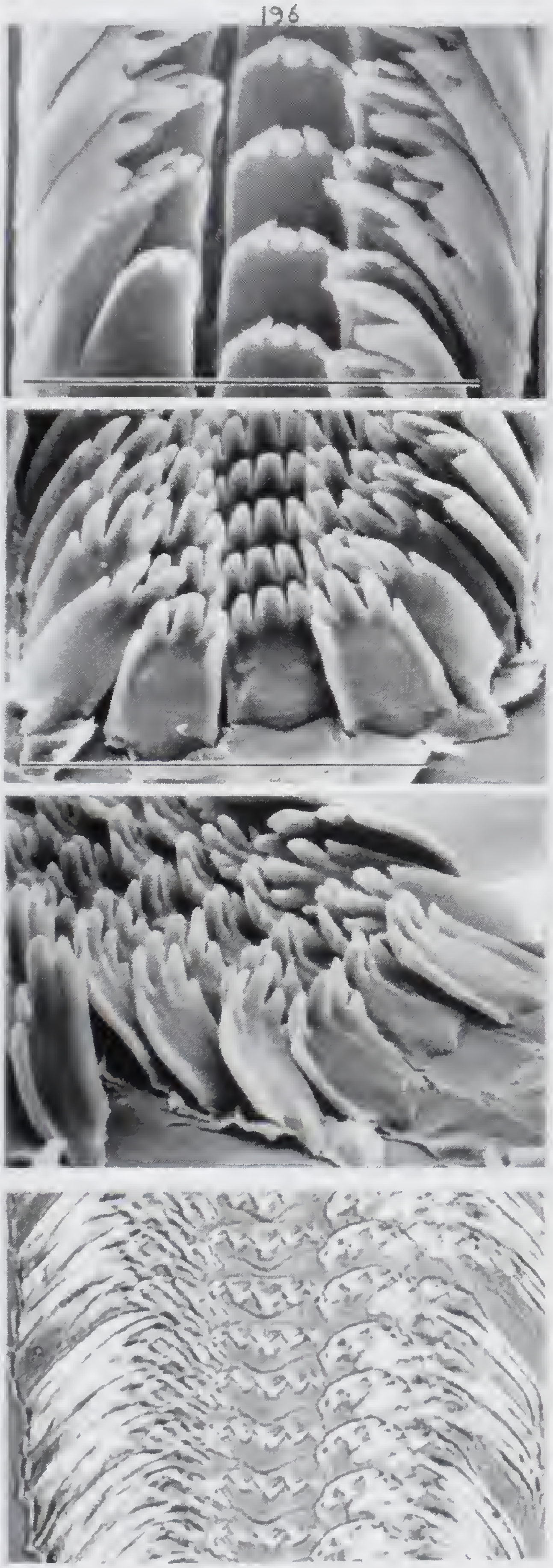


Figure 185. *Blasicrura summersi*

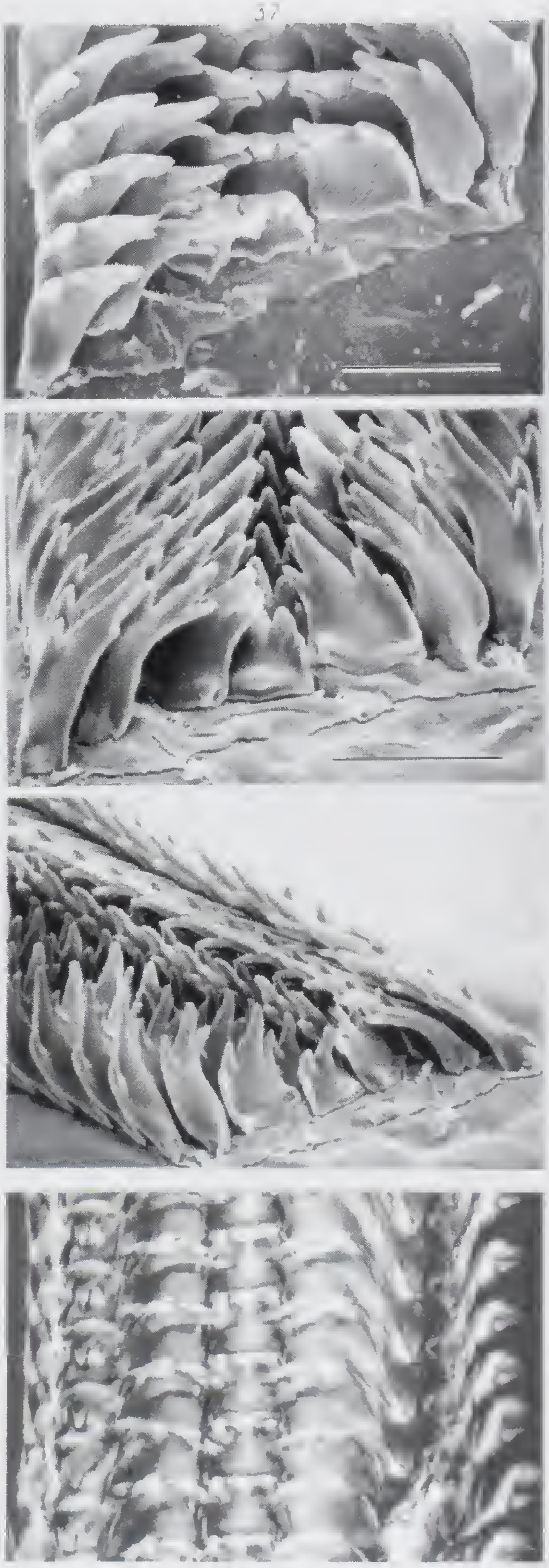


Figure 186. *Nucleolaria cassiaui*

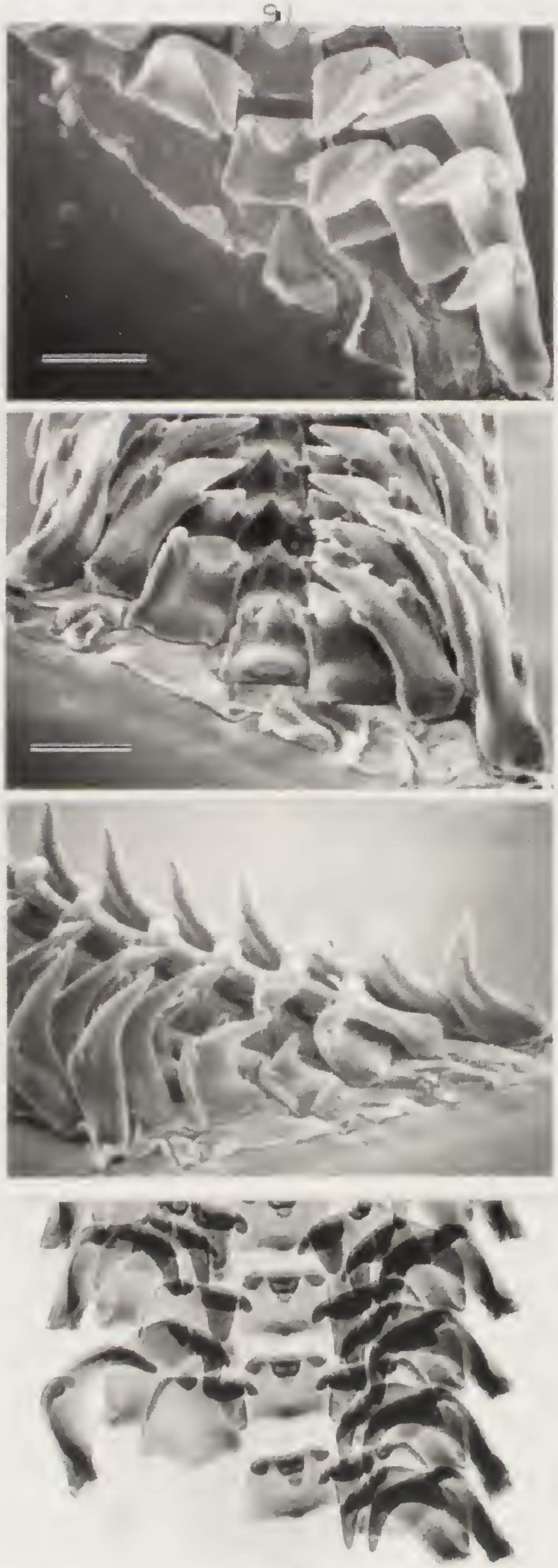


Figure 187. *Nucleolaria granulata*

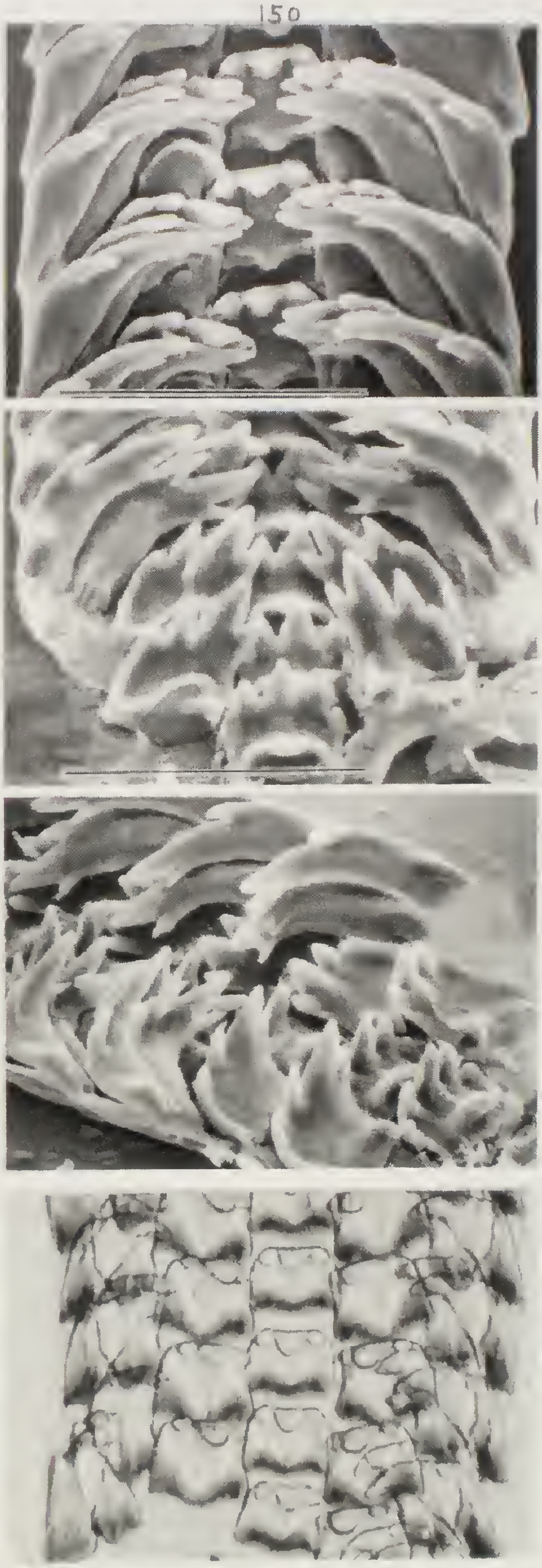


Figure 188. *Nucleolaria nucleus*

218

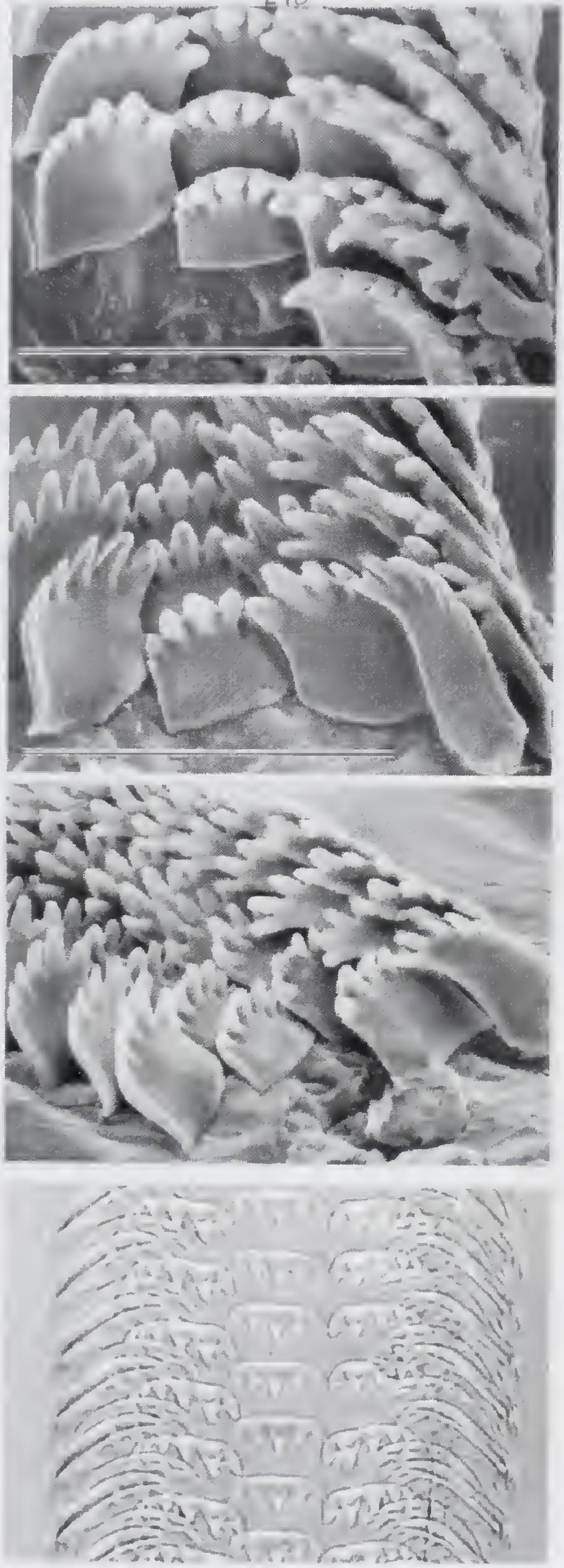


Figure 189. *Palmadusta yaloka*

186 a

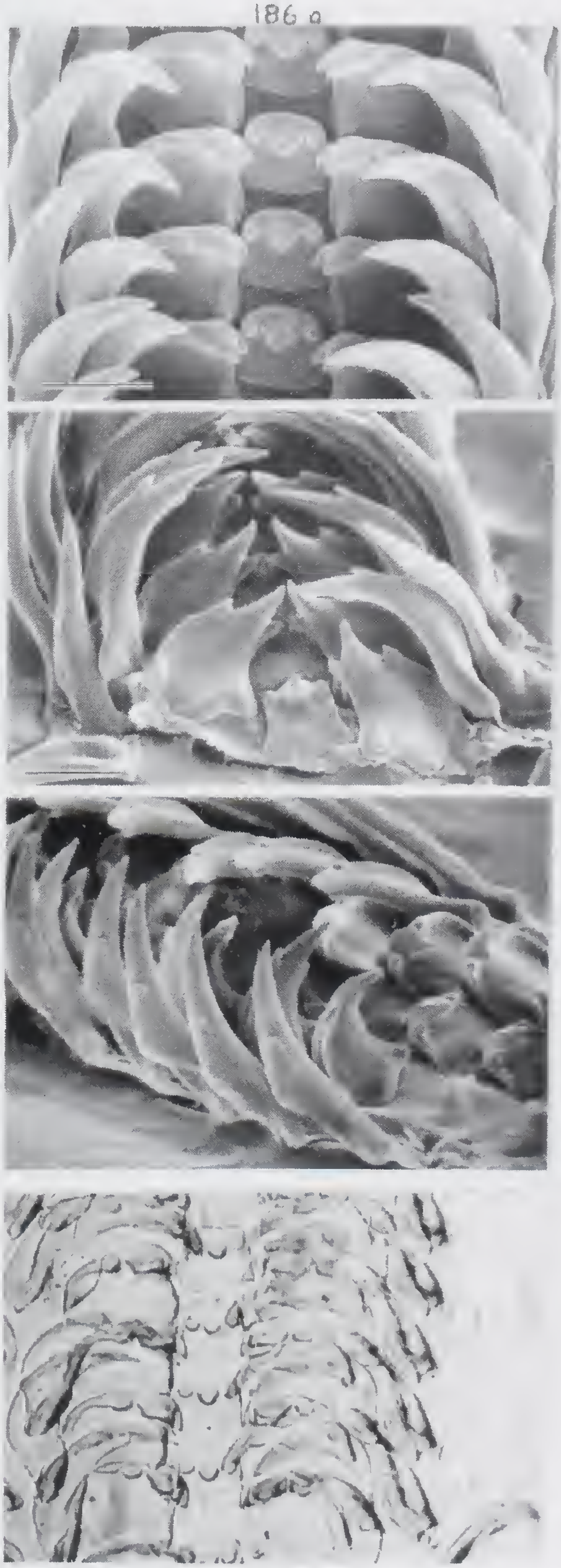


Figure 190. *Staphylaea semiplota*

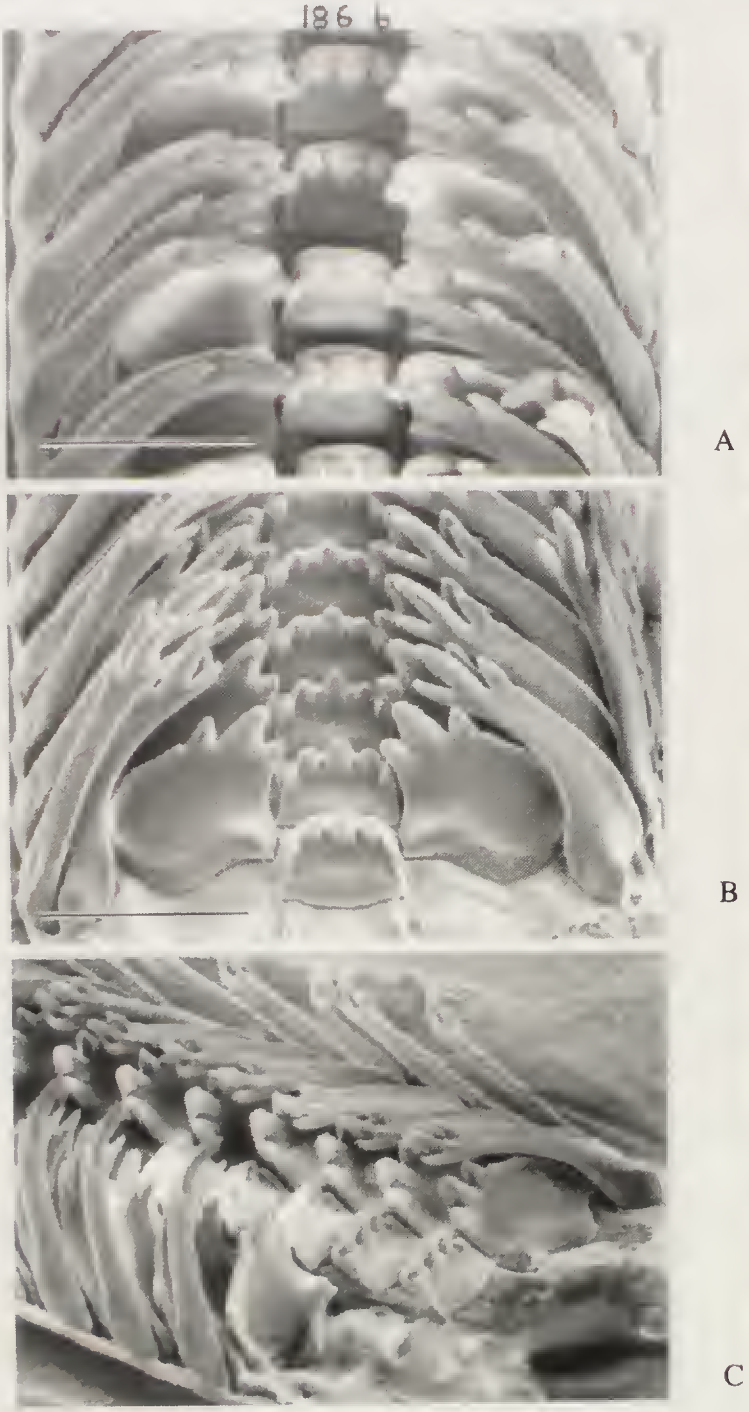


Figure 191. *Staphylaea semiplota*

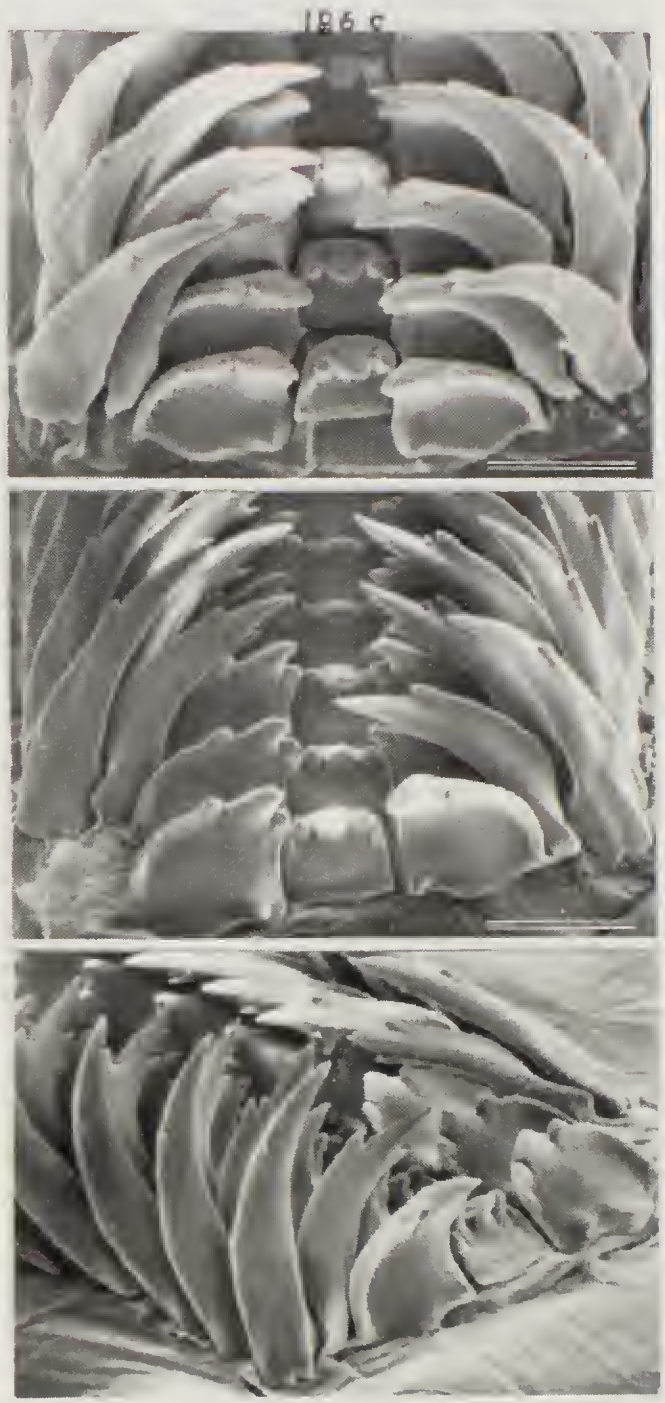


Figure 192. *Staphylaea semiplota annae*

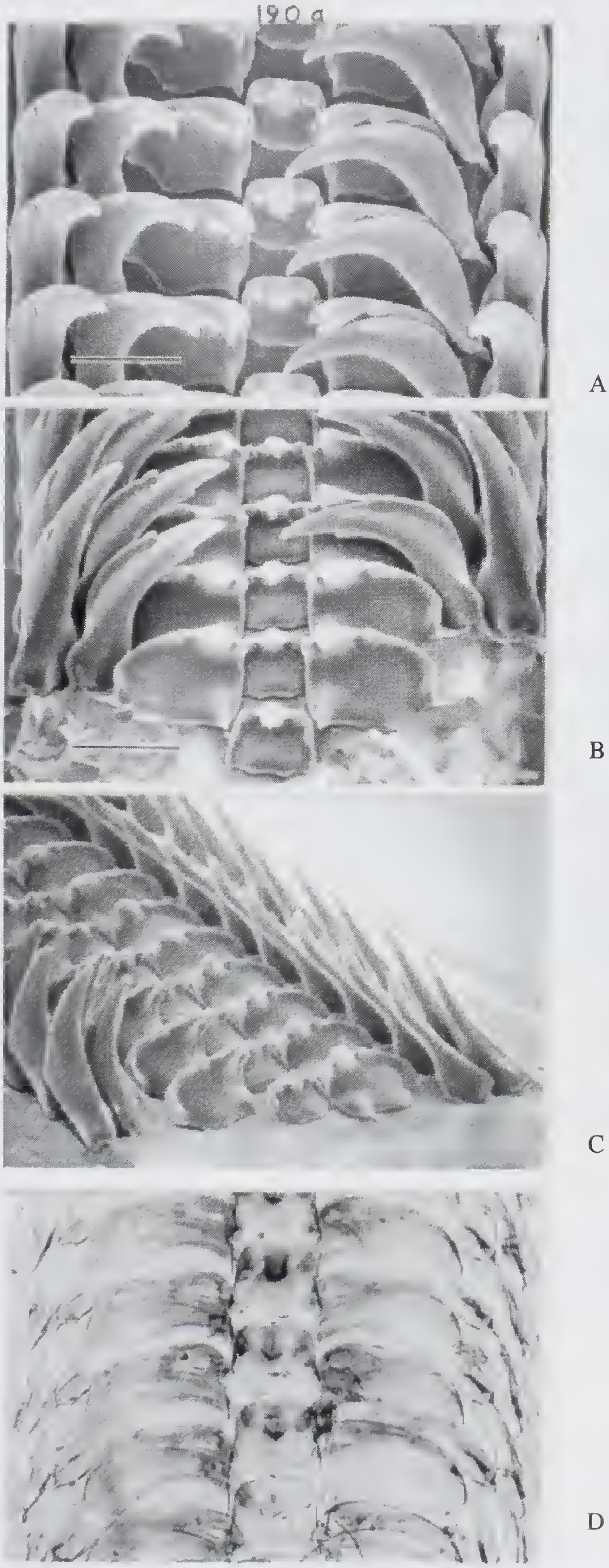


Figure 193. *Staphylaea staphylaea*

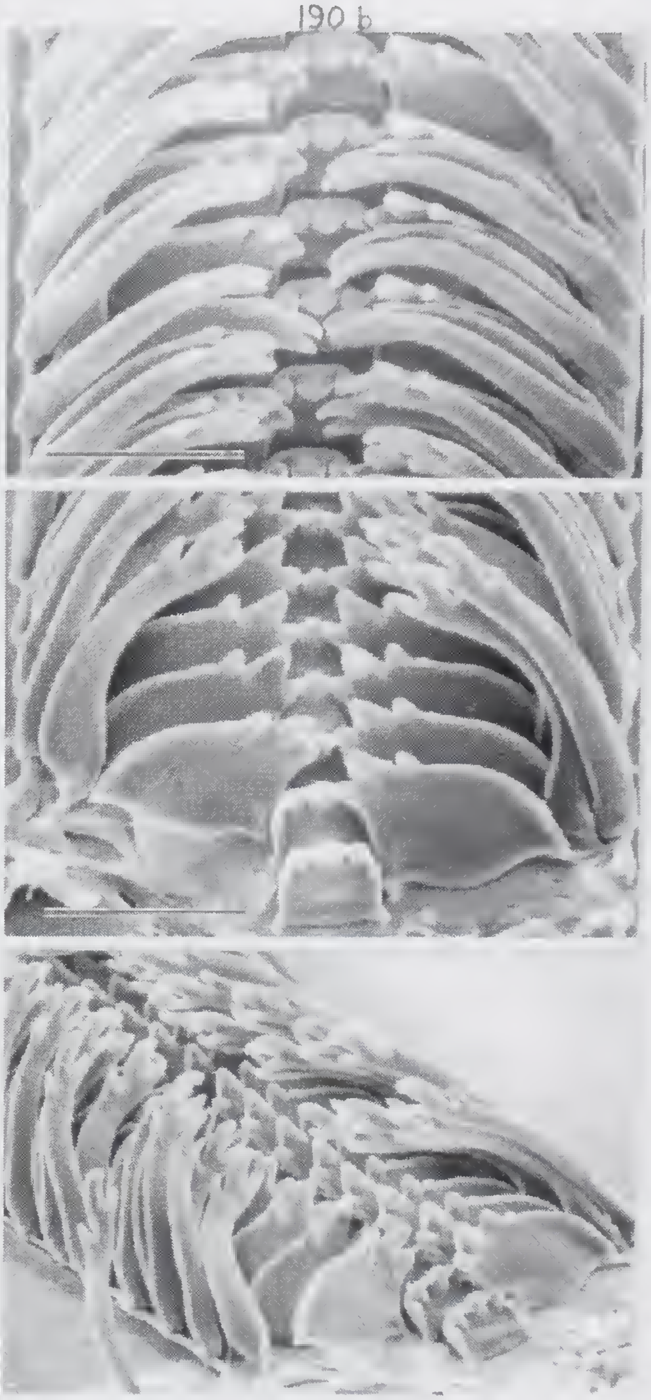
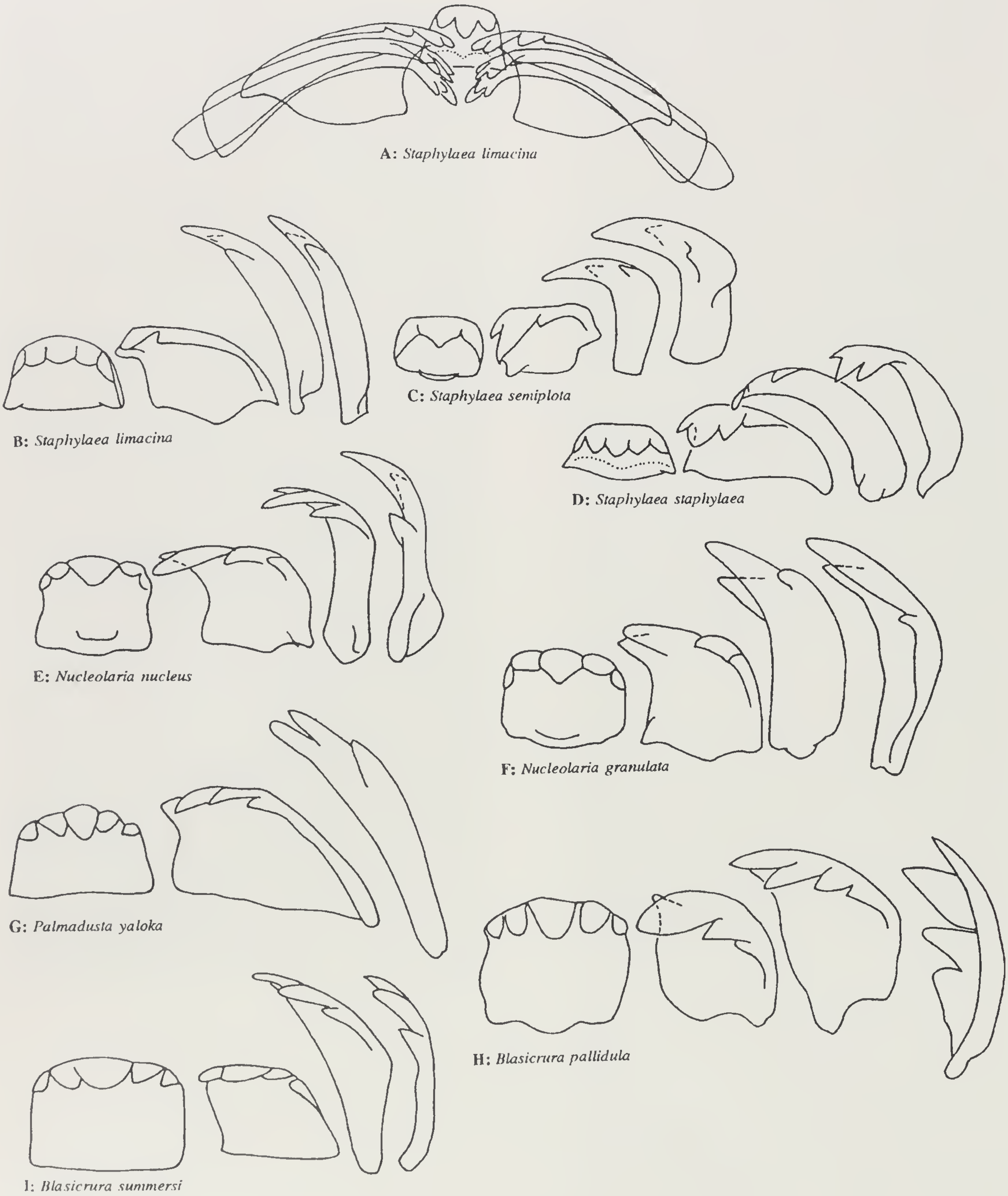


Figure 194. *Staphylaea staphylaea*



A: *Staphylaea limacina*

B: *Staphylaea limacina*

C: *Staphylaea semiplota*

D: *Staphylaea staphylaea*

E: *Nucleolaria nucleus*

F: *Nucleolaria granulata*

G: *Palmadusta yaloka*

H: *Blasicrura pallidula*

I: *Blasicrura summersi*

Figure 195. Limacina pattern drawings

The Cicercula Pattern (Figures 105, 196-238).
Model species: *Pustularia cicercula* (Linnaeus, 1758).

Species: *Blasicrura interrupta* (Gray, 1824); *Cribrarula astaryi* Schilder, 1971; *C. catholicorum* F. Schilder & M. Schilder, 1938; *C. cribellum* (Gaskoin, 1949); *C. cribraria* (Linnaeus, 1758); *C. cumingii* (Sowerby, 1832); *C. esontropia* (Duclos, 1833); *C. fallax* (Smith, 1881); *C. gaskoini* (Reeve, 1846); *Notocypraea angustata* (Gmelin, 1791); *N. bicolor* (Gaskoin, 1849); *N. comptonii* (Gray, 1847); *N. declivis* (Sowerby, 1870); *N. mayi* (Beddome, 1898); *N. piperita* (Gray, 1825); *N. pulicaria* (Reeve, 1846); *N. trenberthae* (Trenberth, 1961); *Palmadusta artuffeli* (Jousseaume, 1876); *P. asellus* (Linnaeus, 1758); *P. clandestina* (Linnaeus, 1767); *P. contaminata* (Sowerby, 1832); *P. diluculum* (Reeve, 1845); *P. lentiginosa* (Gray, 1825); *P. lutea* (Gmelin, 1791); *P. saulae* (Gaskoin, 1843); *P. ziczac* (Linnaeus, 1758); *P.* (*Purpuradusta*) *fimbriata* (Gmelin, 1791); *P.* (*P.*) *gracilis* (Gaskoin, 1849); *P.* (*P.*) *hammondae* (Iredale, 1939); *P.* (*P.*) *microdon* (Gray, 1828); *P.* (*P.*) *minoridens* (Melvill, 1901); *P.* (*P.*) *serrulifera* F. Schilder & M. Schilder, 1938; *Propustularia surinamensis* (Perry, 1811); *Pustularia* (*Annepona*) *mariae* Schilder, 1927; *P. bistrinotata* (F. Schilder & M. Schilder, 1937); *P. cicercula* (Linnaeus, 1758); *P. globulus* (Linnaeus, 1758); *P. margarita* (Dillwyn, 1817); *P. mauiensis* (Burgess, 1967).

The cicercula pattern is defined by the five-cusp central tooth which also bears a pair of mid-shaft denticles. In the array of 38 species assigned to six genera, the central tooth is small, less than 100 microns, except in *Notocypraea*: (mean dimensions 126x114 microns; n=8), one specimen of *Propustularia surinamensis* (125x130 microns; n=1), and one specimen of *Palmadusta* (*P. gracilis* 125x100 microns; n=1). Mean dimensions are 68.3x54.4 microns (n=9) in *Cribrarula*; 60.8x56.5 microns (n=24) in *Palmadusta*; and 48.3x47.8 microns (n=9) in *Pustularia*. L/w ratios are close to 1.0. (1.1 in *Pustularia;* n=9); (1.1 in *Blasicrura interrupta*; n=1); (1.23 in *Cribrarula;* n=9); (1.11 in *Notocypraea;* n=8); (1.1 in *Palmadusta;* n=9); (0.98 in *Propustularia surinamensis;* n=1). An internal bract is usually present. The teeth are crowded, with the marginals and laterals overlapping. The laterals approximate the size of the central tooth, but are often slightly wider, and there are four cusps and paired basal denticles, the inner directed toward the central tooth. The marginals are blade-like in *Blasicrura interrupta*, *Palmadusta artuffeli, P. clandestina*, *P. contaminata*, *P. (Purpuradusta) fimbriata*, *P. (P.) gracilis*, *P. (P.) hammondae*, *P. (P.) microdon*, *P. ziczac*, *Pustularia bistrinotata*, *P. cicercula*, *P. globulus*, and *P. mauiensis*; long and thin in *Palmadusta asellus*, *P. diluculum*, *P. lentiginosa*, *P. lutea*, *P. (Purpuradusta) minoridens*, *P. saulae*, and *Propustularia surinamensis*. Figure 203 shows a normal specimen of *Cribrarula esontropia* from La Réunion. Figure 204 shows a specimen from Mauritius with extra cusps on the left marginal teeth. Figure 205 shows the teeth of a Madagascar cowrie tentatively identified as *Cribrarula esontropia.* The similarity to the teeth of Figures 203 and 205 gives strong indication of a range extension to this species. The teeth of *Pustularia mariae* are similar to the lynx pattern, but the five cusps on the central and the paired mid-shaft denticles warrant inclusion in the cicercula pattern. The lateral cusps on the central tooth in *Propustularia surinamensis* are not well developed, but are evident at the lateral edges of the central tooth.

Central tooth dimensions: 95x70 microns (n=9) in *Cribrarula*; 175x120 microns (n=8) in *Notocypraea*; 125x100 microns (n=24) in *Palmadusta*; 125x130 microns (n=1) in *Propustularia surinamensis*; 35x35 to 70x60 microns (n=9) in *Pustularia.*
No. of radular rows: 95 to 160 (n=6).
No. of radular rows per mm radula: 11.4 to 40.5 (n=22).

Except for the eight species in *Notocypraea* which are endemic to Australia and *Propustularia surinamensis* of the Caribbean, the species displaying this pattern all occur in the Indo-West Pacific. The shells are small, about 20 mm in length except for the 30 mm length in *Propustularia surinamensis*. There is a shallow, ribbed fossula in all 39 species. Mantle characters are variable: thick and red with prominent papillae in *Palmadusta fimbriata*, black in *P. asellus*, thin and pale yellow with sparse papillae in *Pustularia*. There is no bursa copulatrix in *Notocypraea* or in *P. fimbriata*. The several whorls of the larval shells in *Cribrarula*, *Palmadusta* and *Propustularia* are indicative of a planktonic larval stage; the two bulbous whorls of the larval shell in *Pustularia* may indicate little or no time in the plankton. The juveniles in *Notocypraea* hatch directly from the egg capsule. Fossils of *Cribrarula* are known from the Pliocene of Fiji; *Notocypraea* only from the early Pliocene of southern Australia. *Palmadusta* is known from the early Pliocene of Japan; *Propustularia* from the late Pleistocene of Southern California; and *Pustularia* from the Miocene of Fiji.

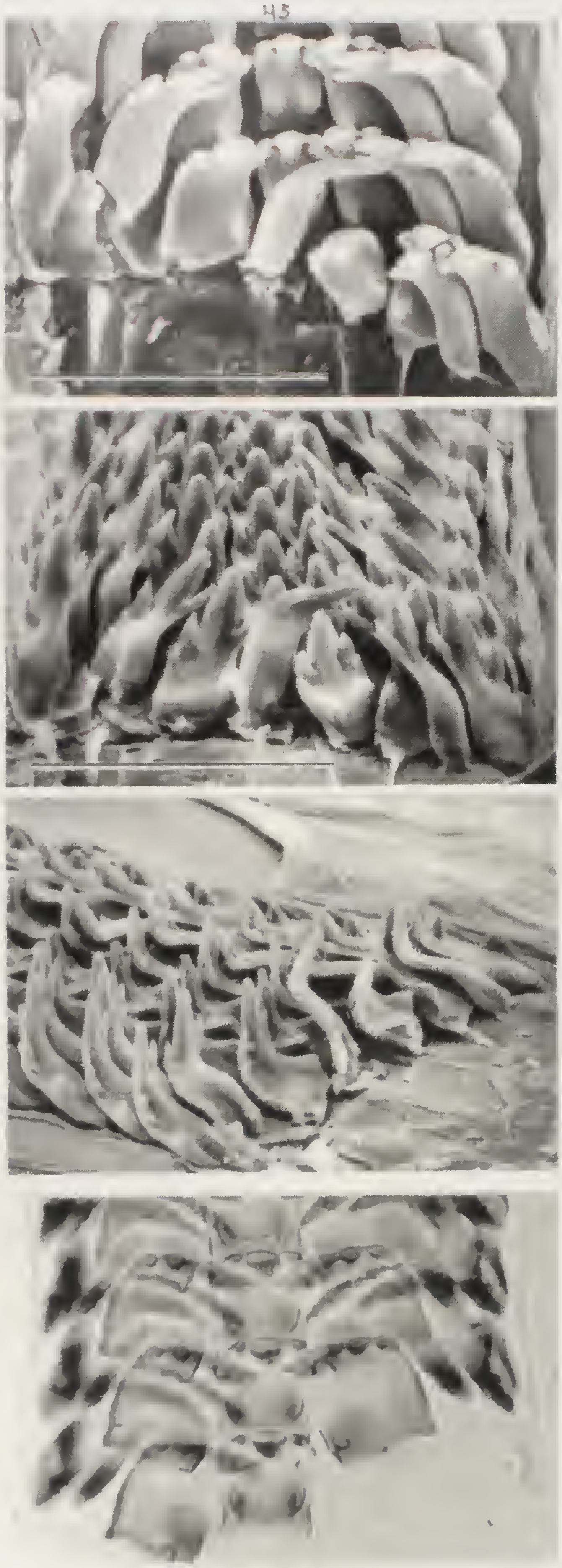


Figure 196. *Pustularia cicercula*

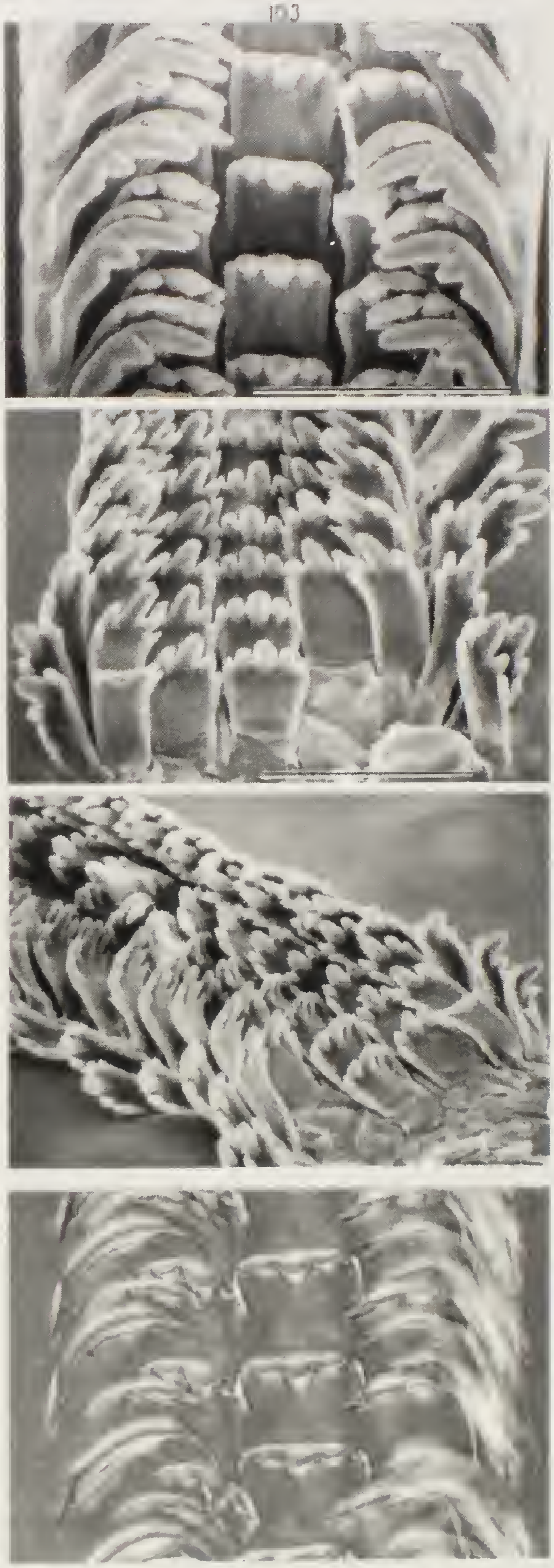


Figure 197. *Blasicrura interrupta*

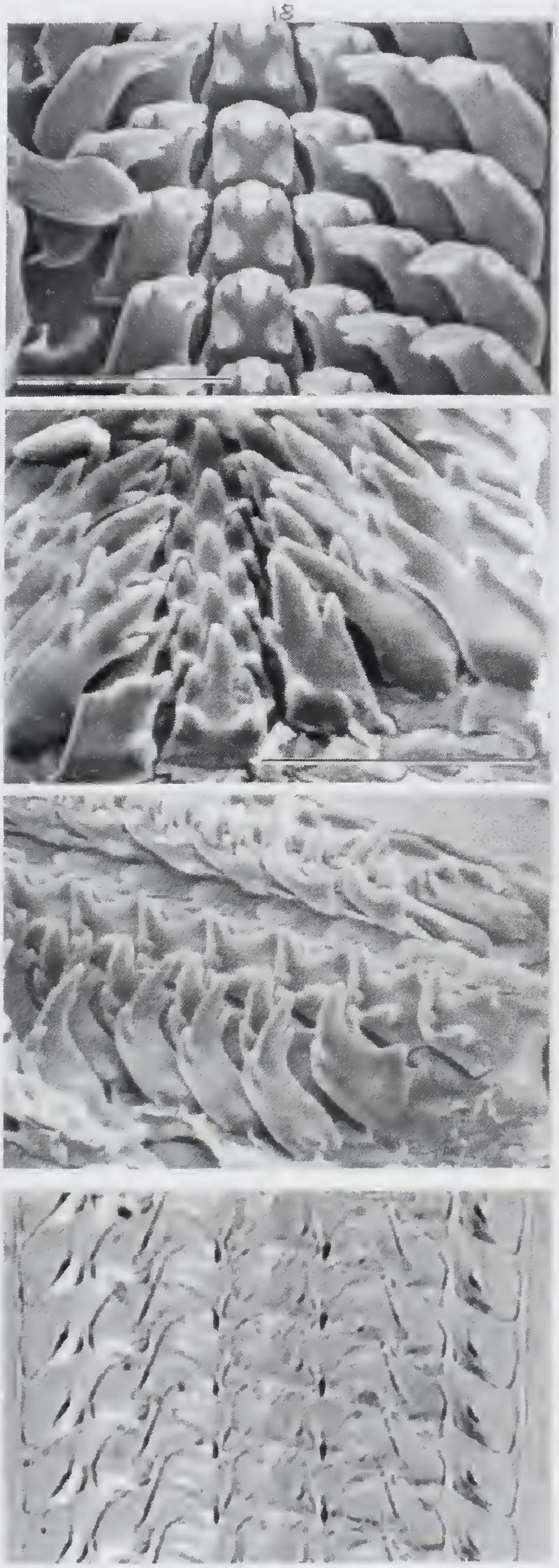


Figure 198. *Cribrarula astaryi*

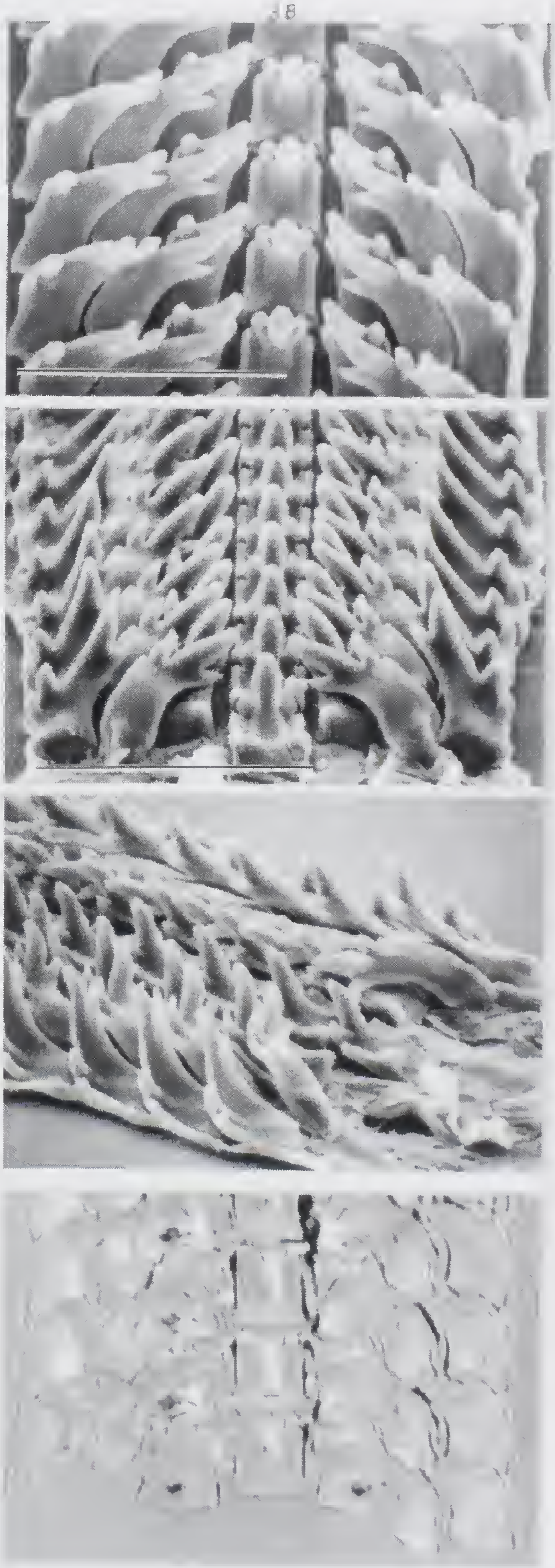


Figure 199. *Cribrarula catholicorum*

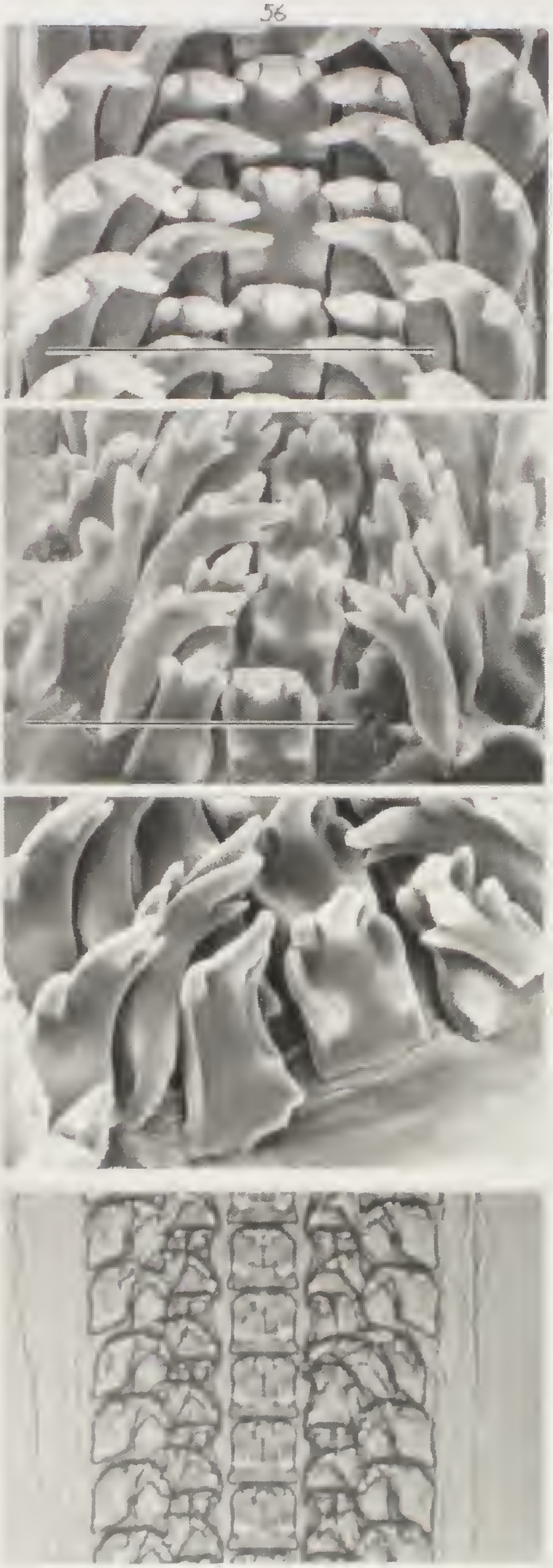


Figure 200. *Cribrarula cribellum*

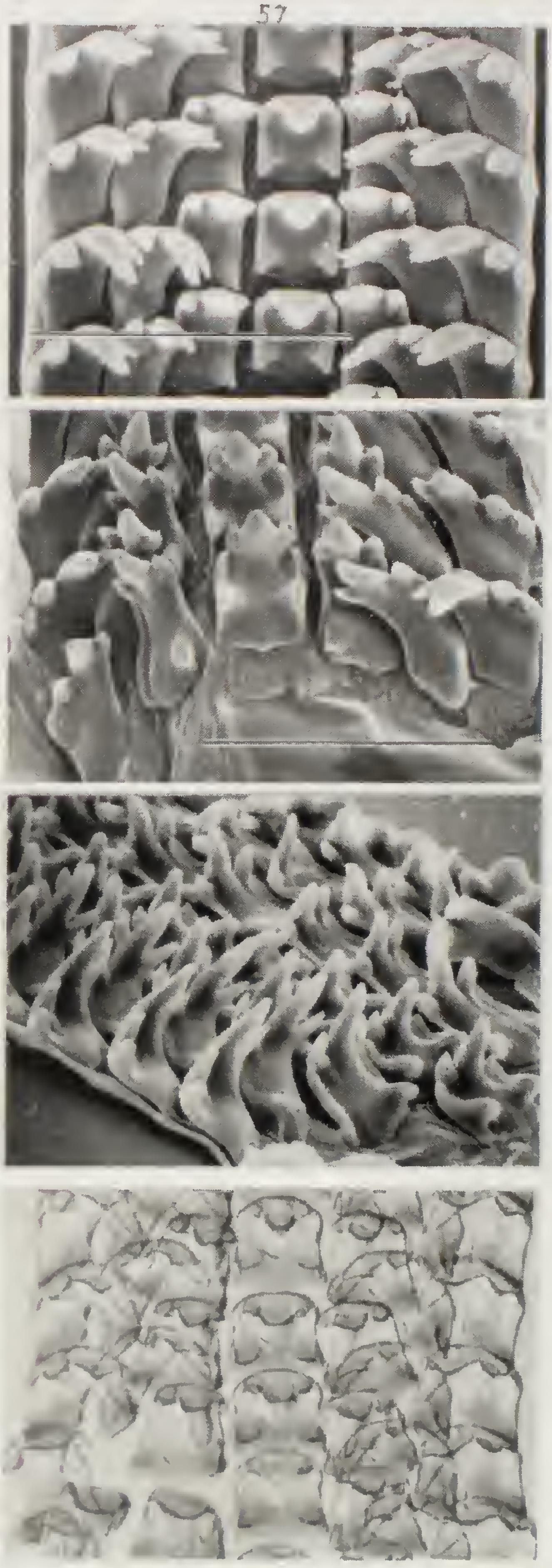


Figure 201. *Cribrarula cribraria*

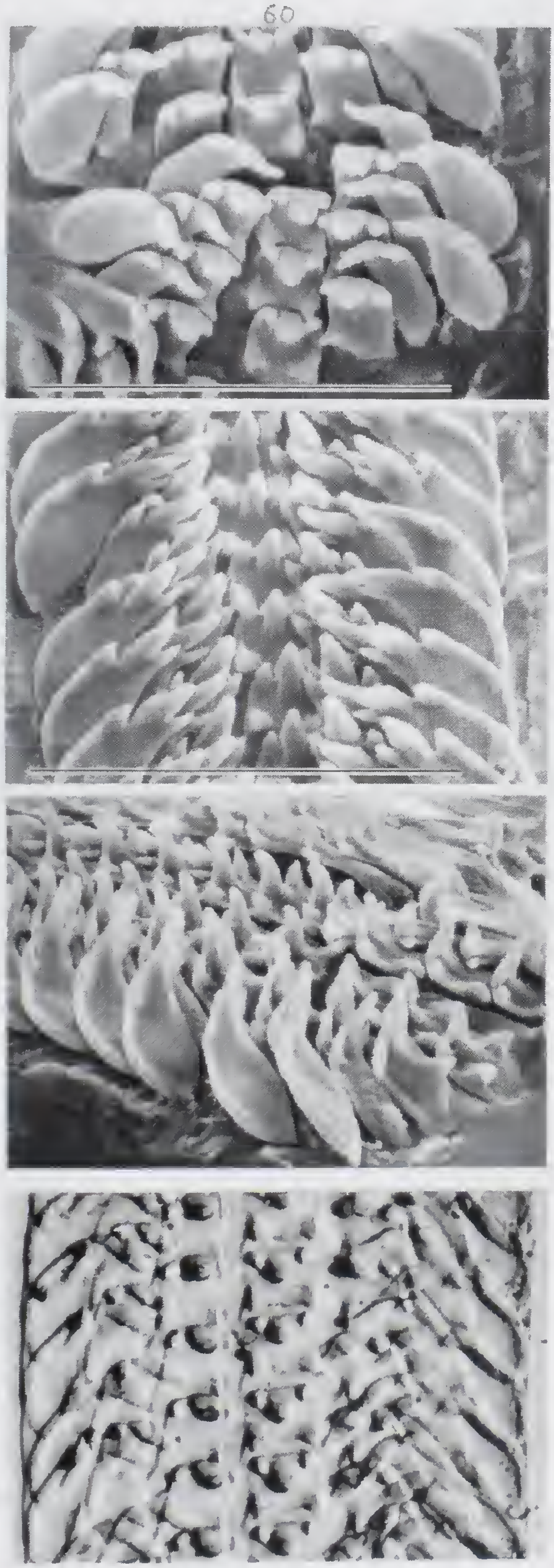


Figure 202. *Cribrarula cumingii*

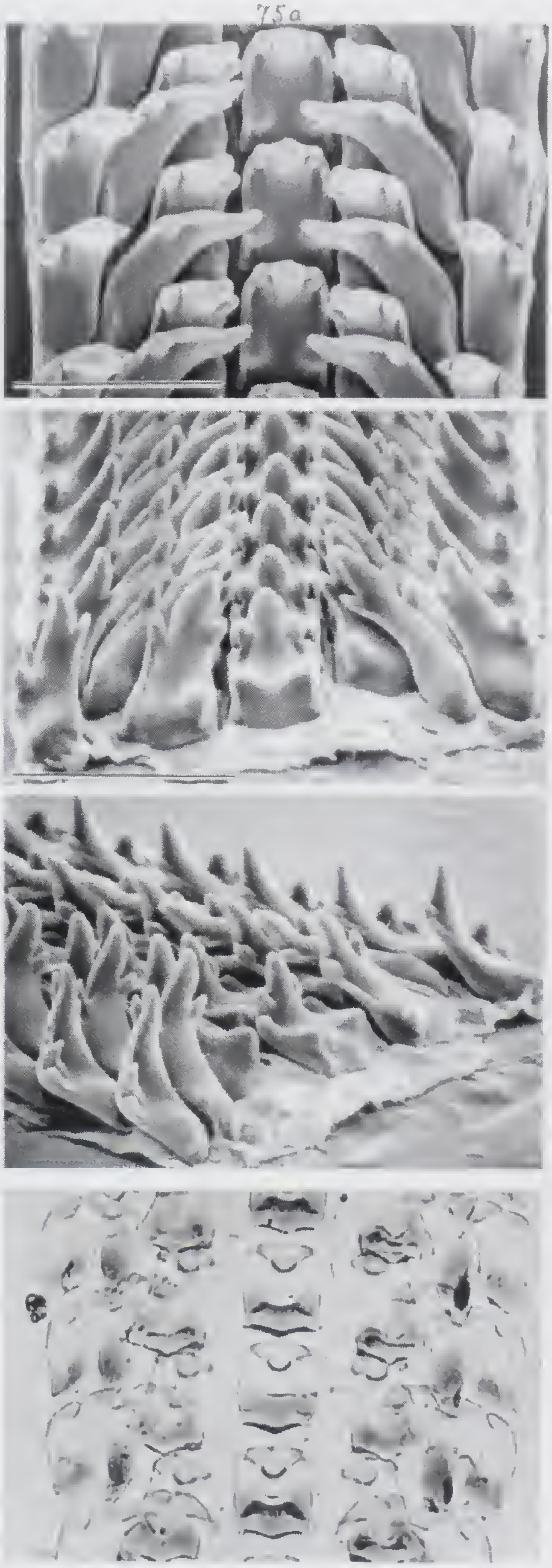


Figure 203. *Cribrarula esontropia*

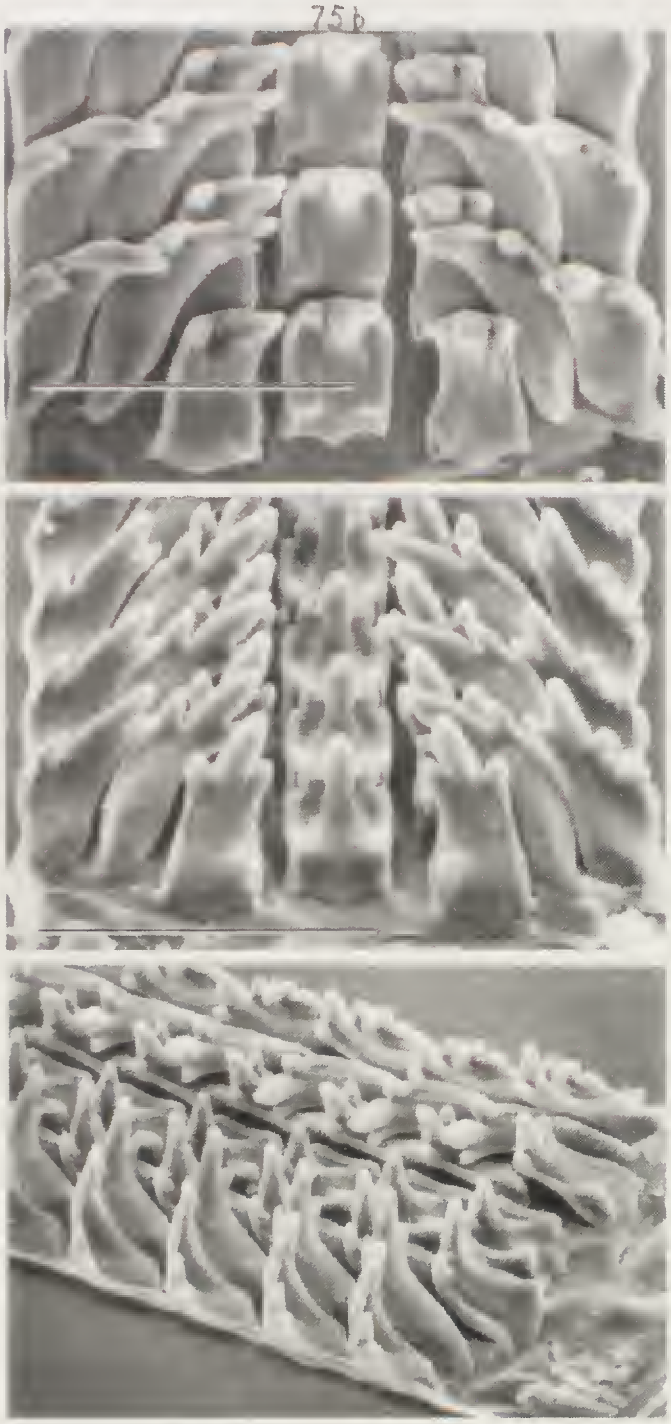


Figure 204. *Cribrarula esontropia*

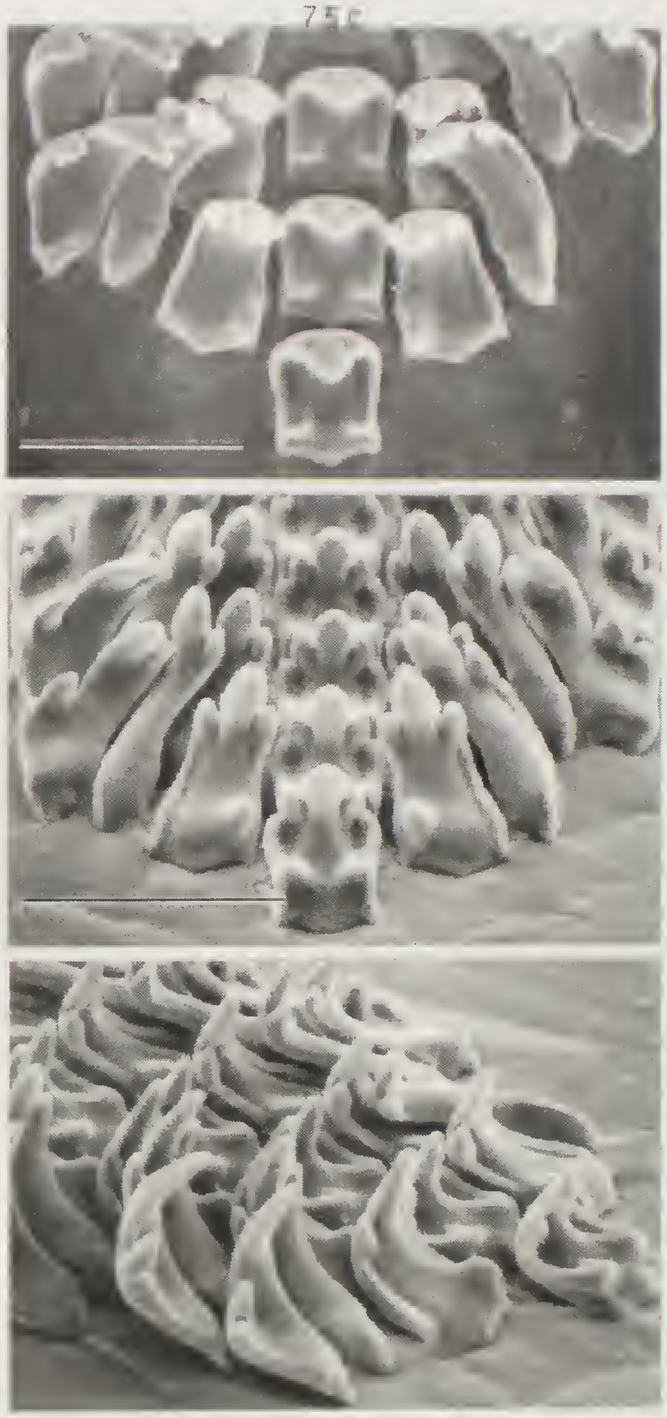


Figure 205. *Cribrarula esontropia*

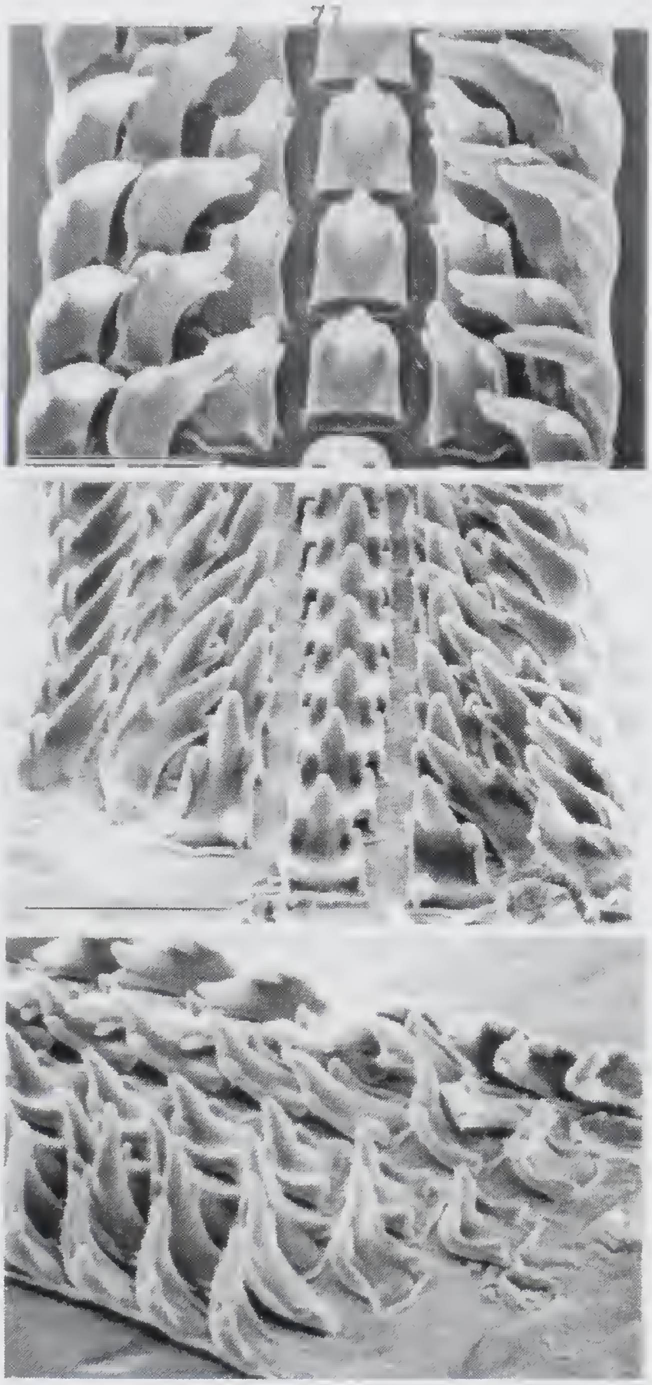


Figure 206. *Cribrarula fallax*

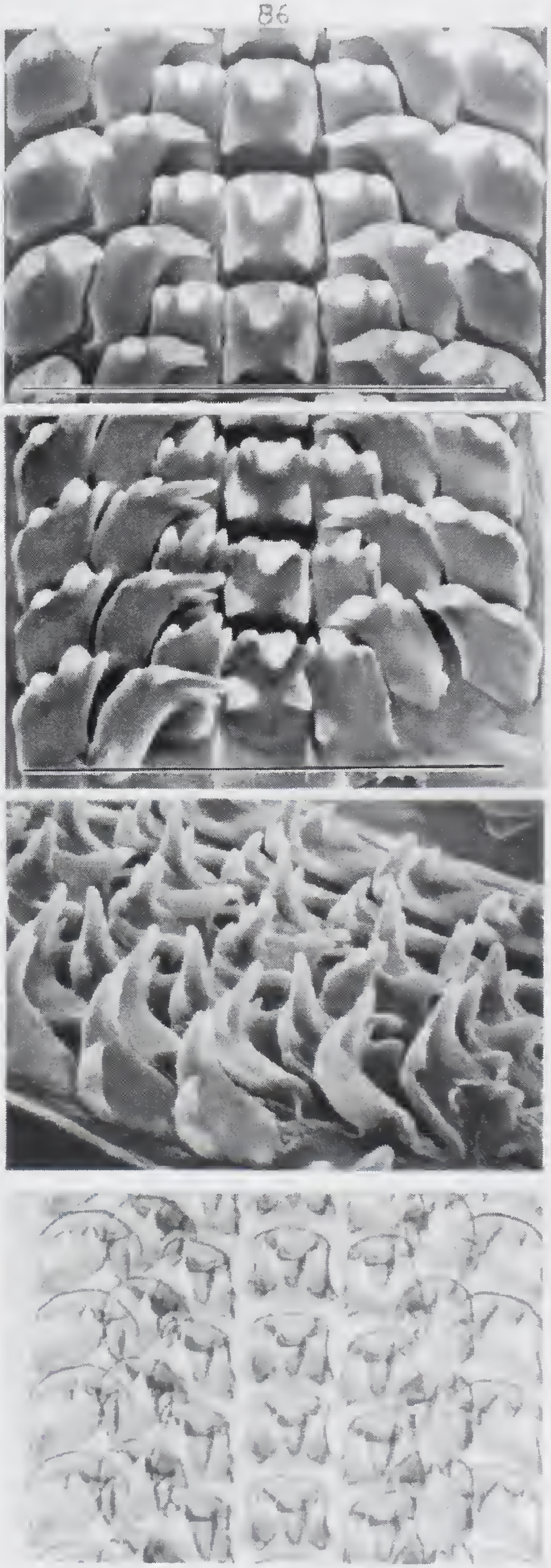


Figure 207. *Cribrarula gaskoini*

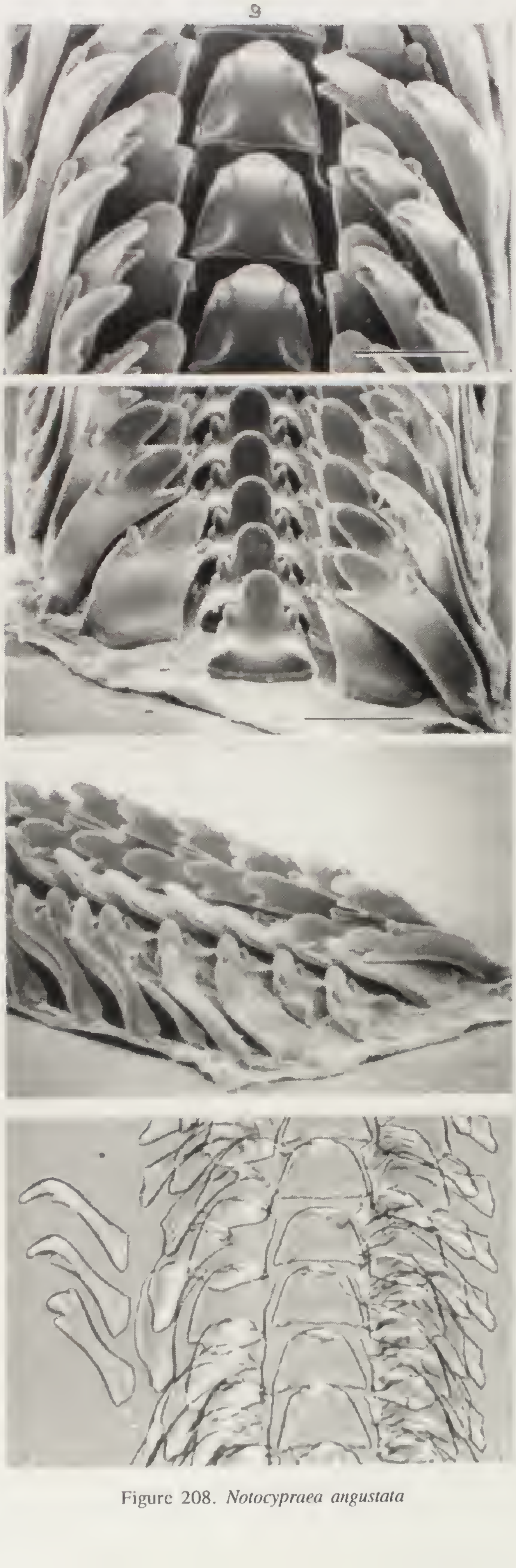


Figure 208. *Notocypraea angustata*

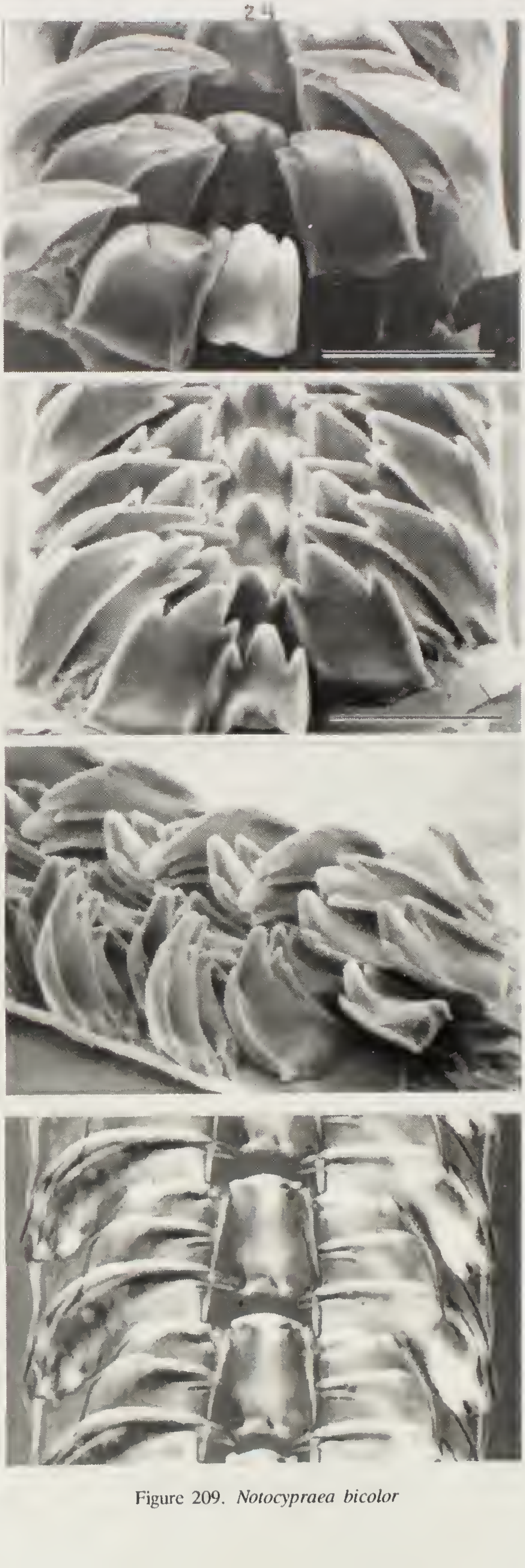


Figure 209. *Notocypraea bicolor*

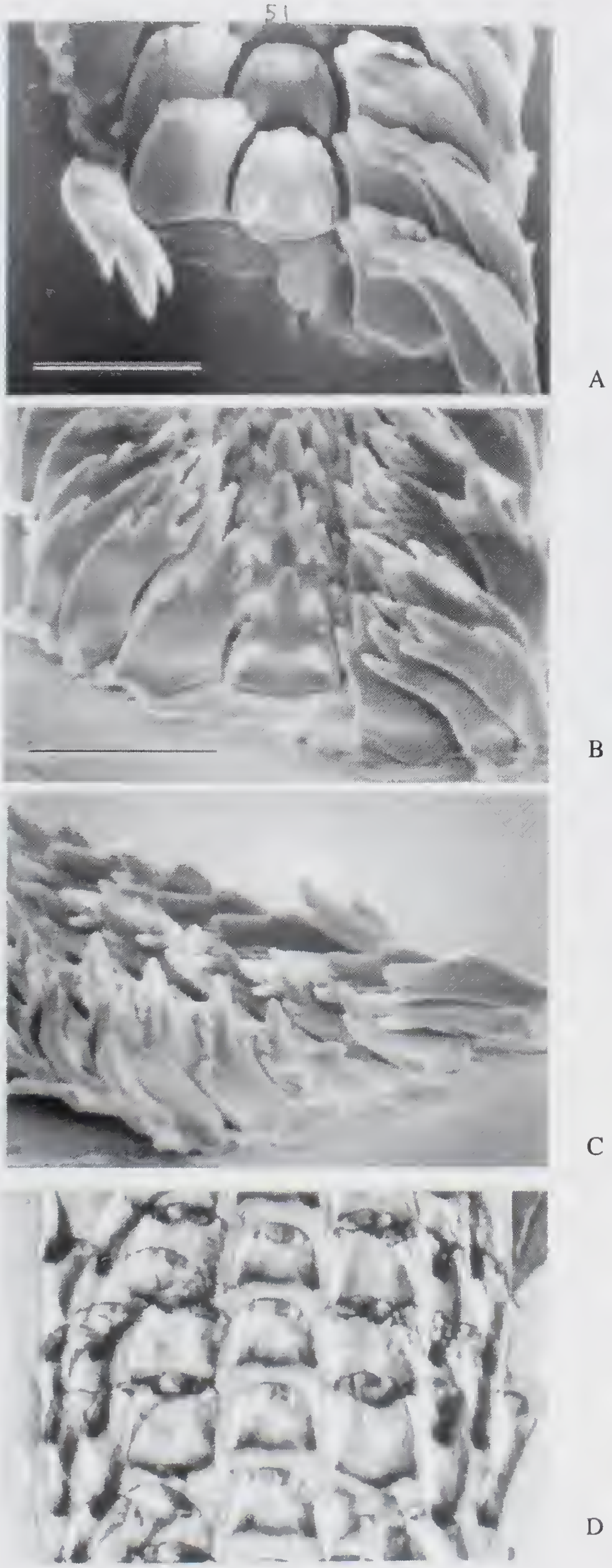


Figure 210. *Notocypraea comptonii*

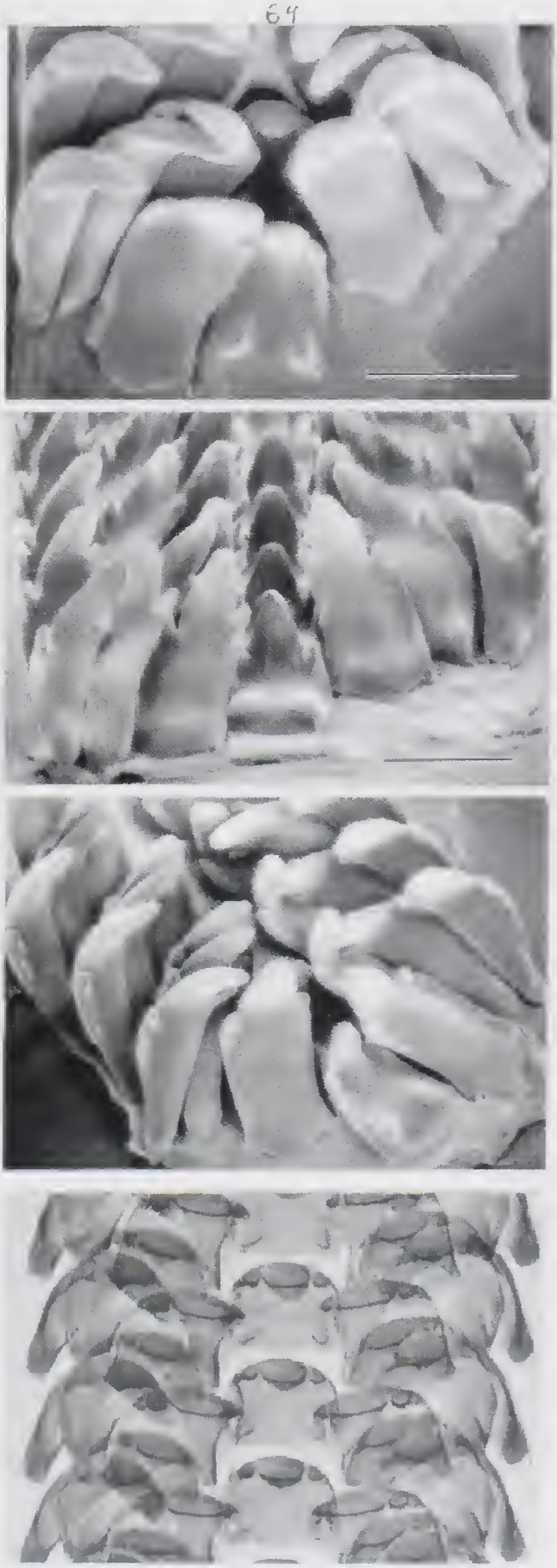


Figure 211. *Notocypraea declivis*

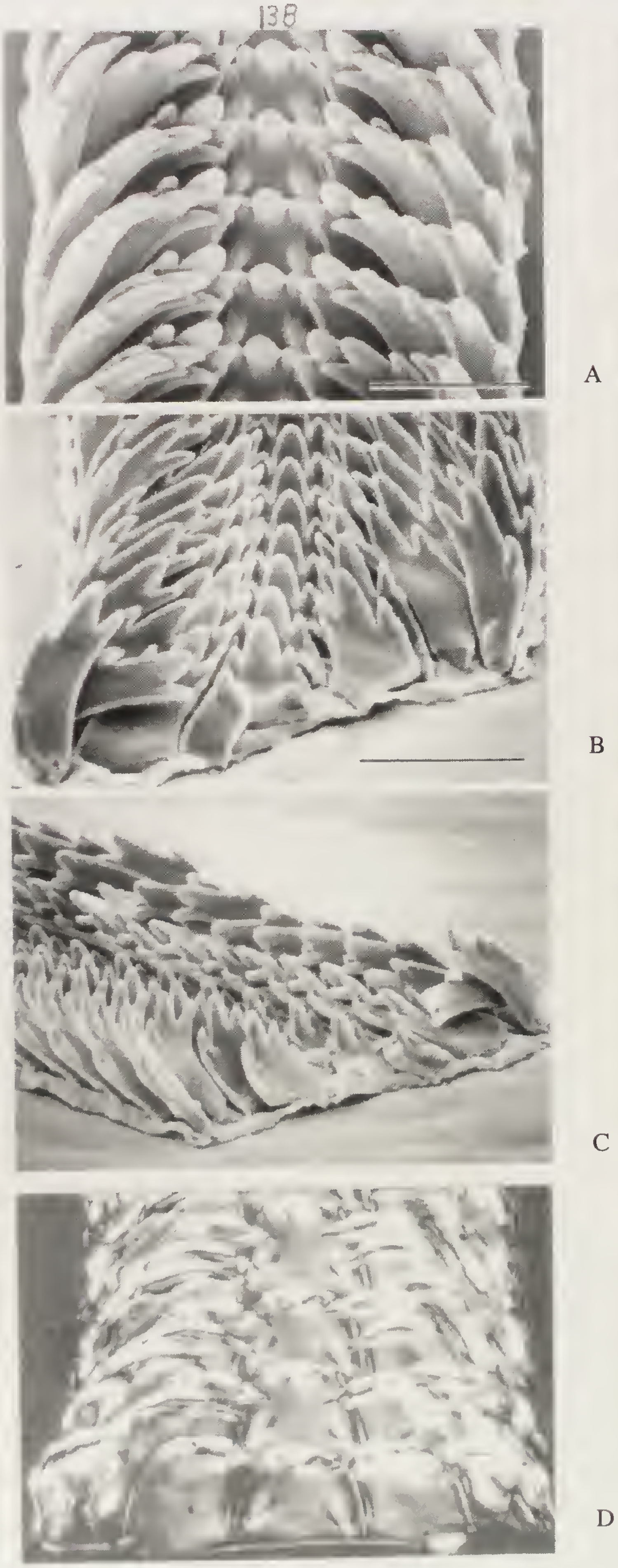


Figure 212. *Notocypraea mayi*

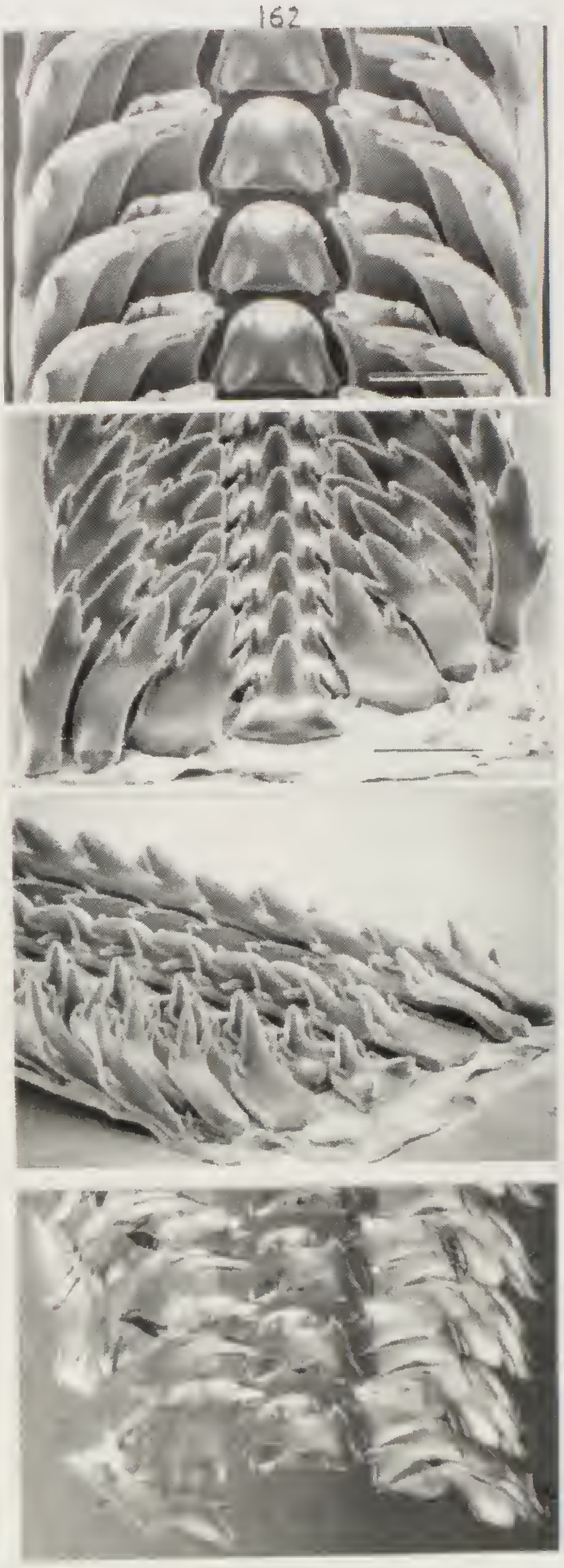


Figure 213. *Notocypraea piperita*

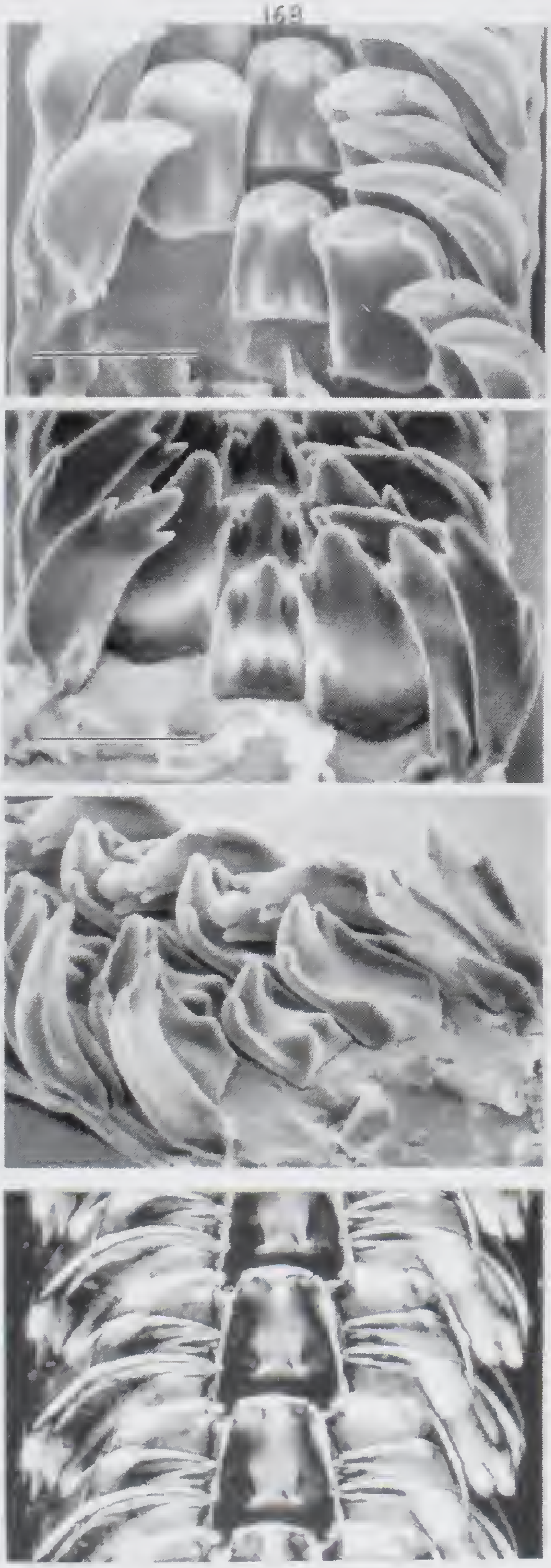


Figure 214. *Notocypraea pulicaria*

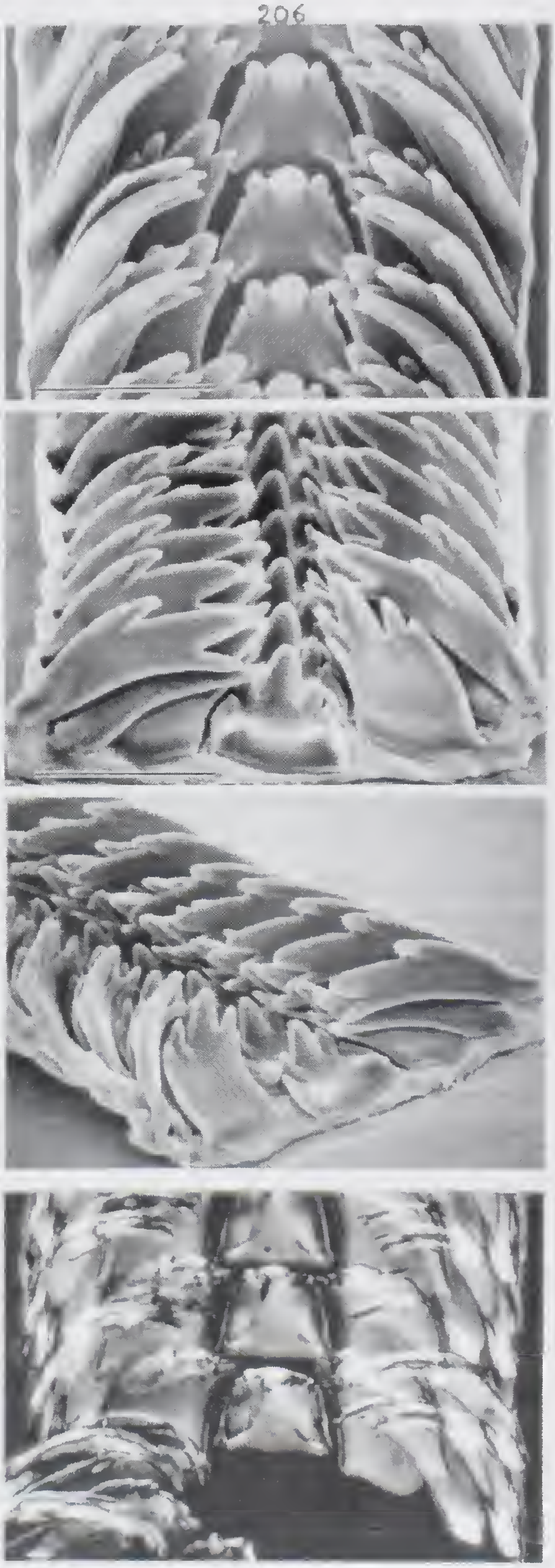


Figure 215. *Notocypraea trenberthae*

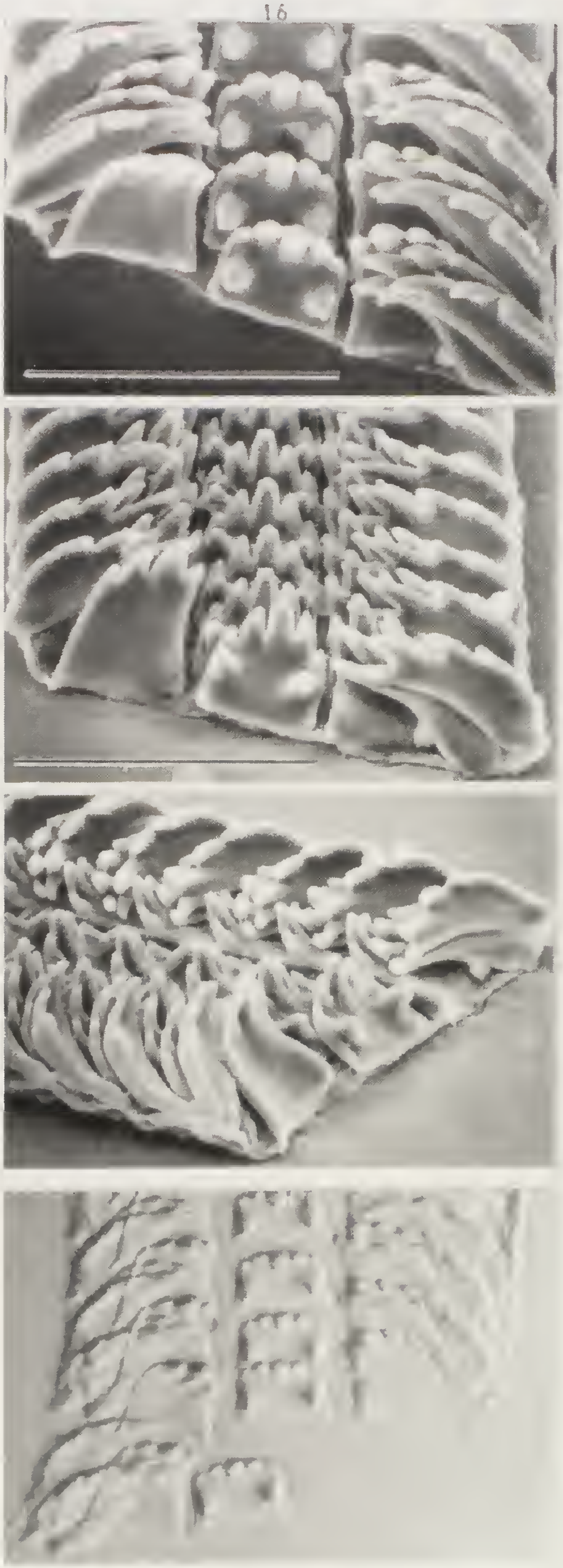


Figure 216. *Palmadusta artuffeli*

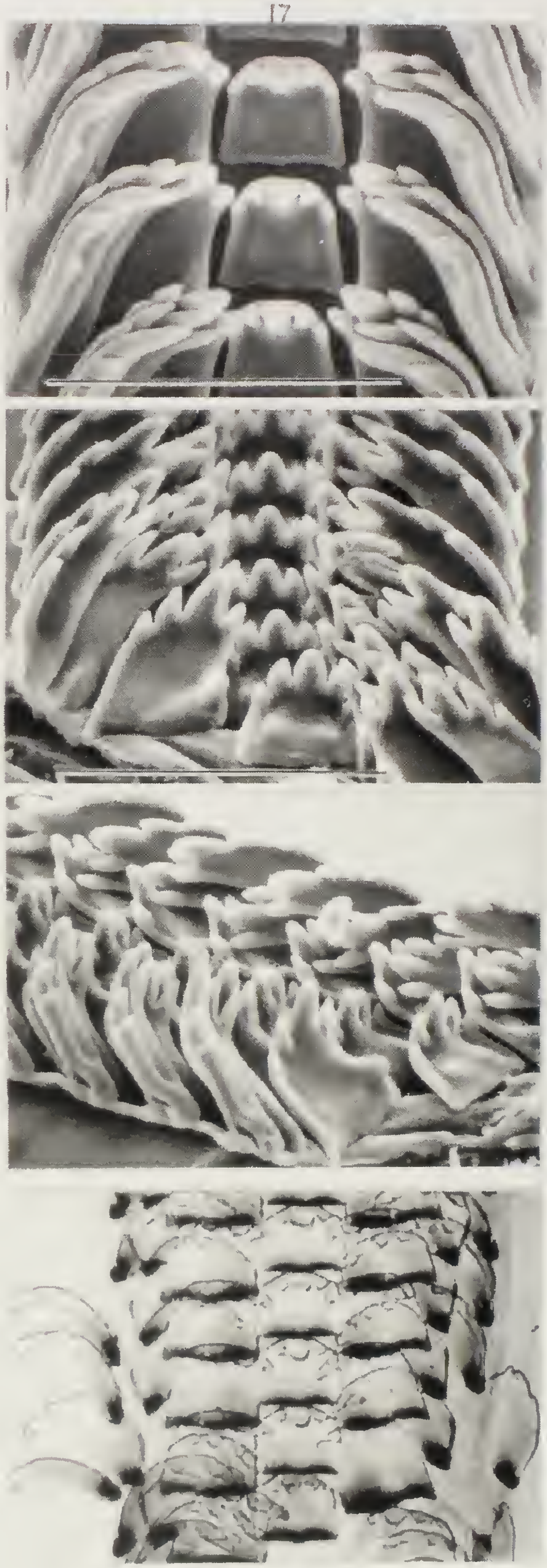


Figure 217. *Palmadusta asellus*

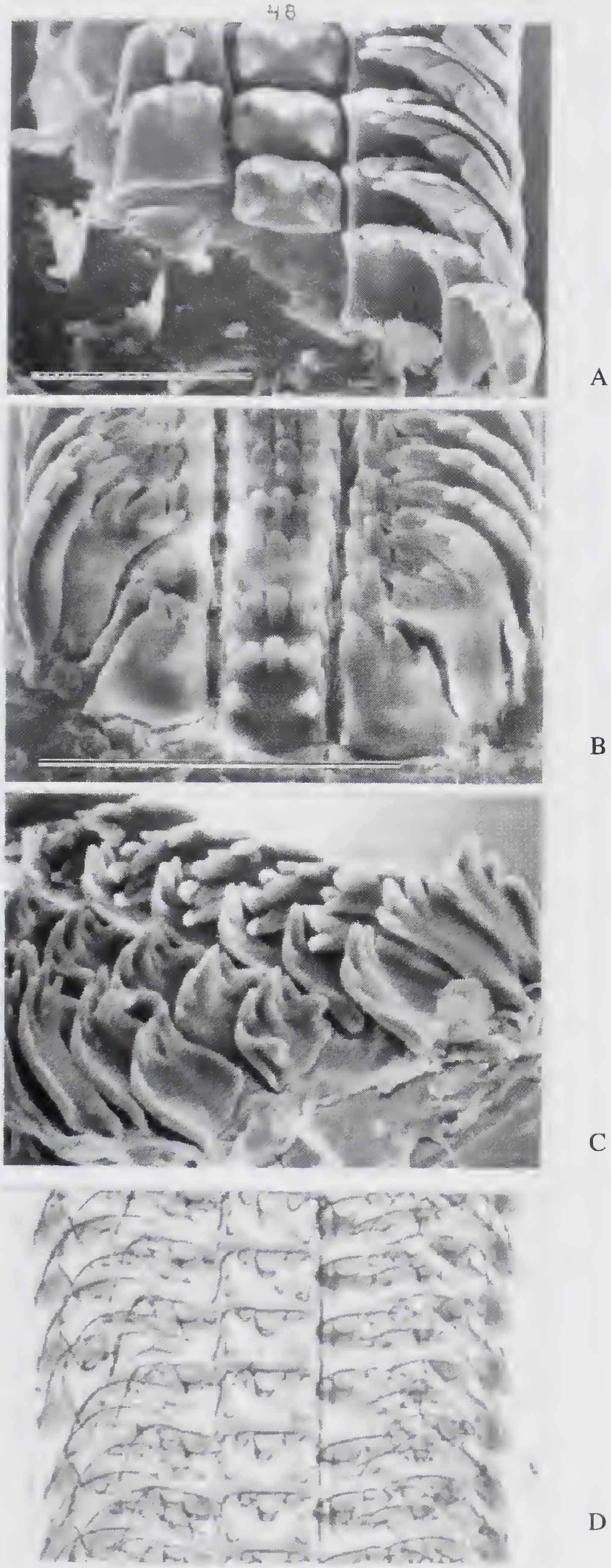


Figure 218. *Palmadusta clandestina*

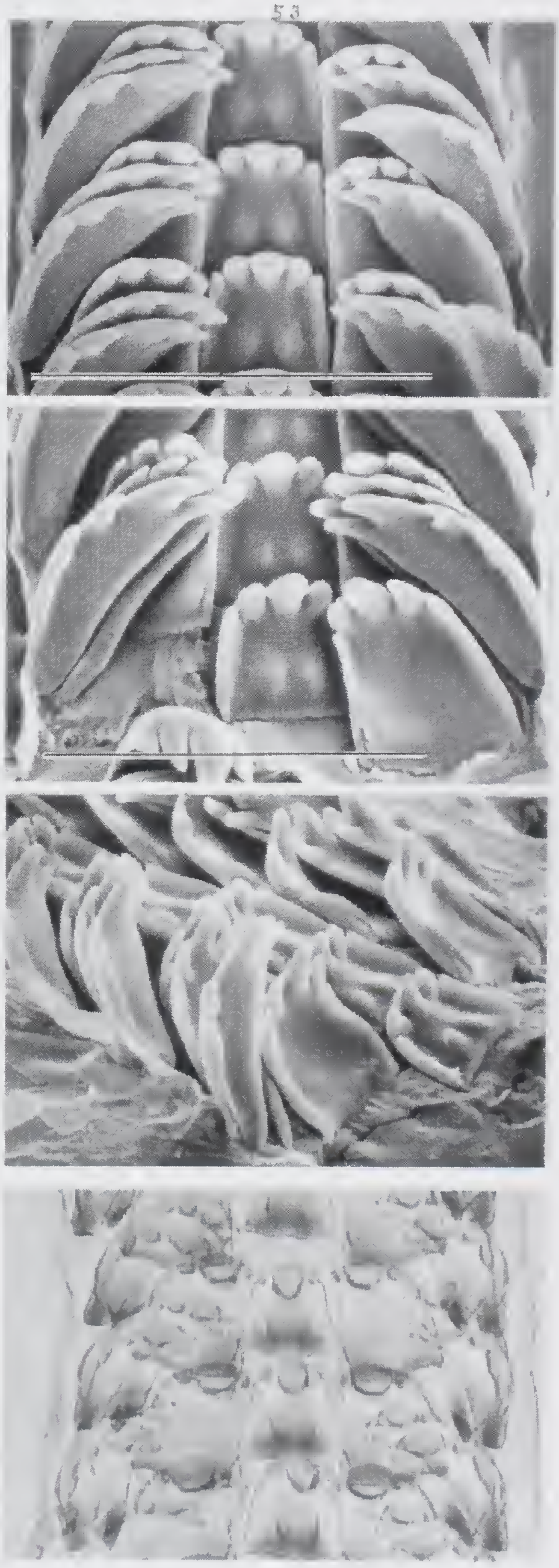


Figure 219. *Palmadusta contaminata*

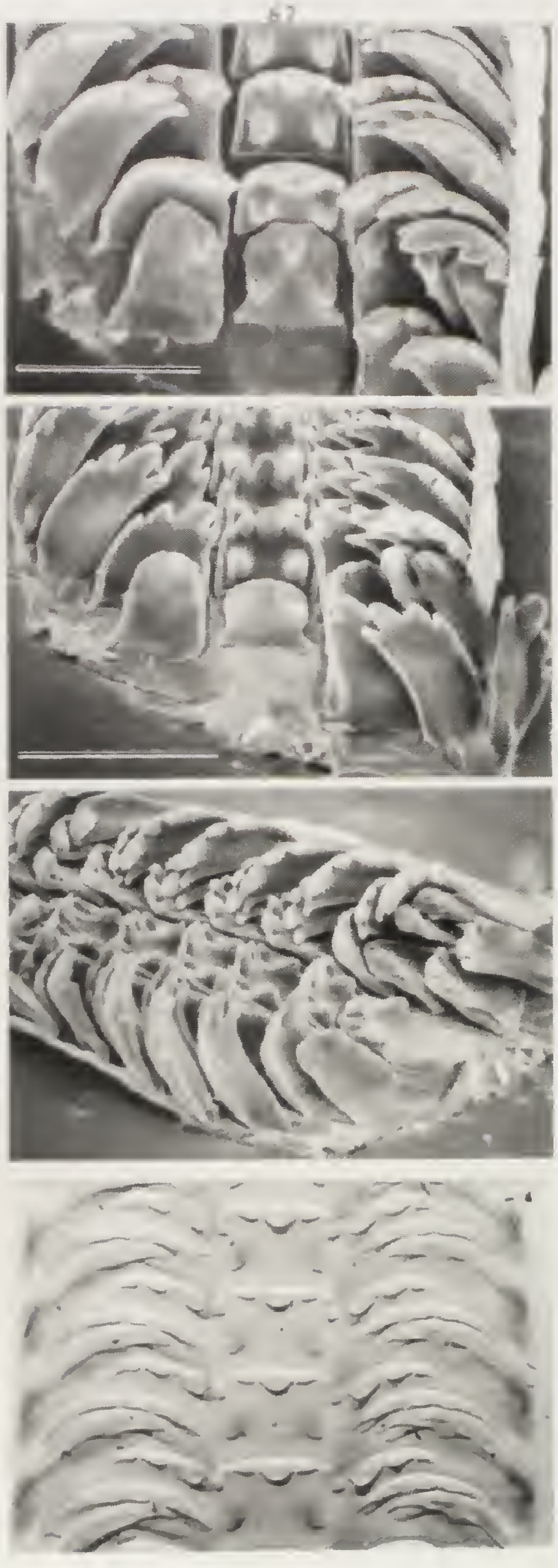


Figure 220. *Palmadusta diluculum*

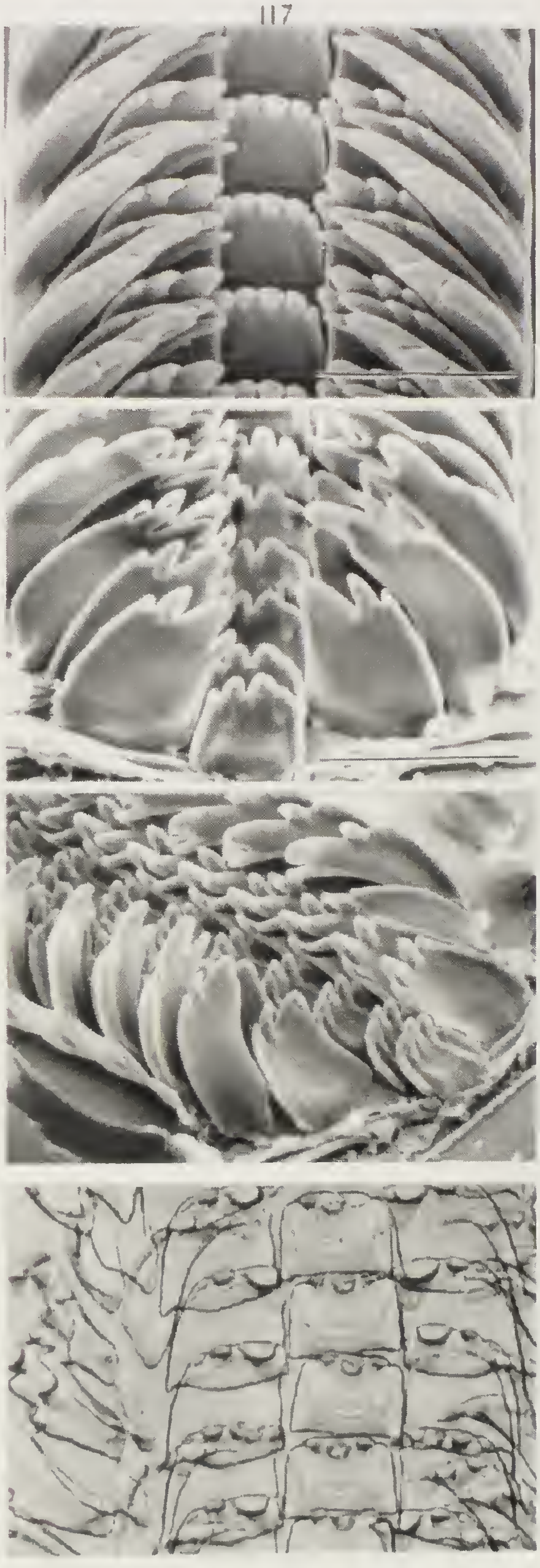


Figure 221. *Palmadusta lentiginosa*

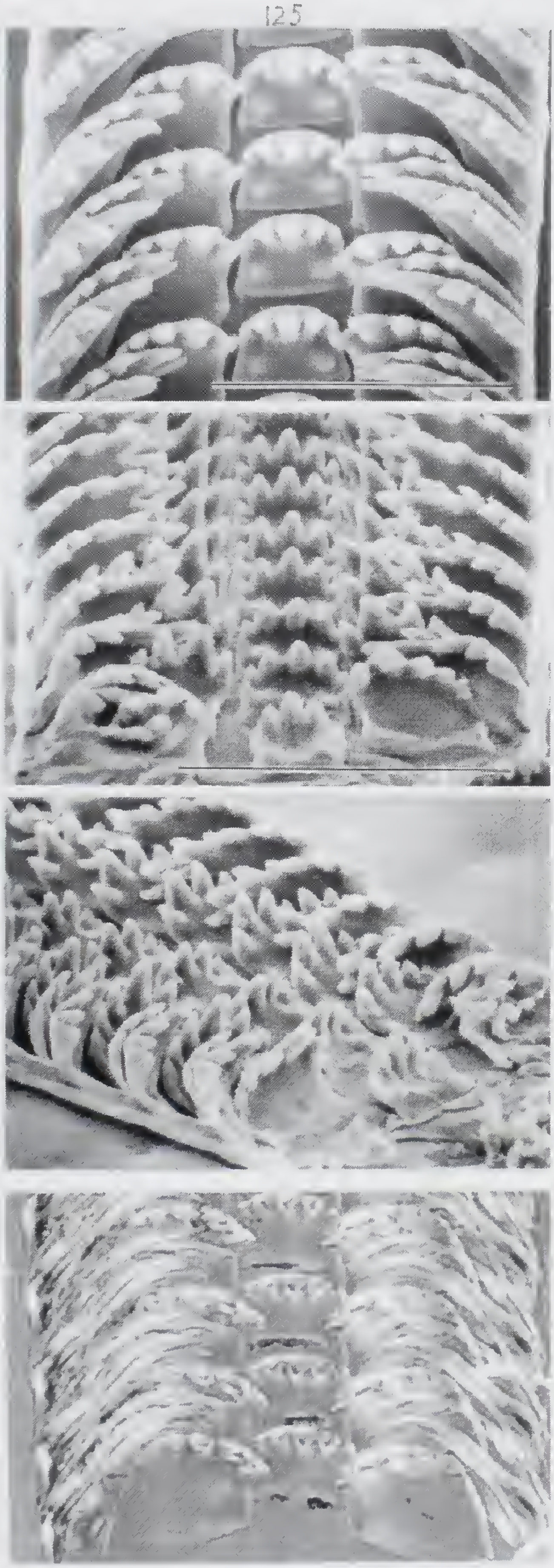


Figure 222. *Palmadusta lutea*

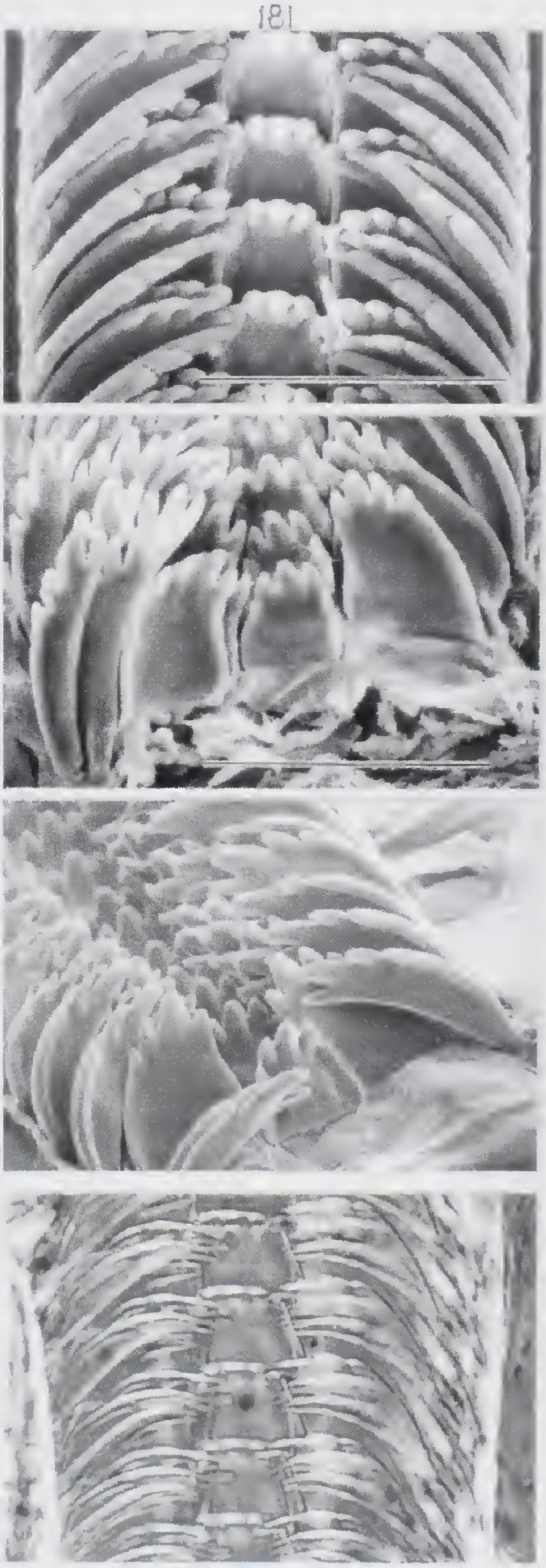


Figure 223. *Palmadusta saulae*

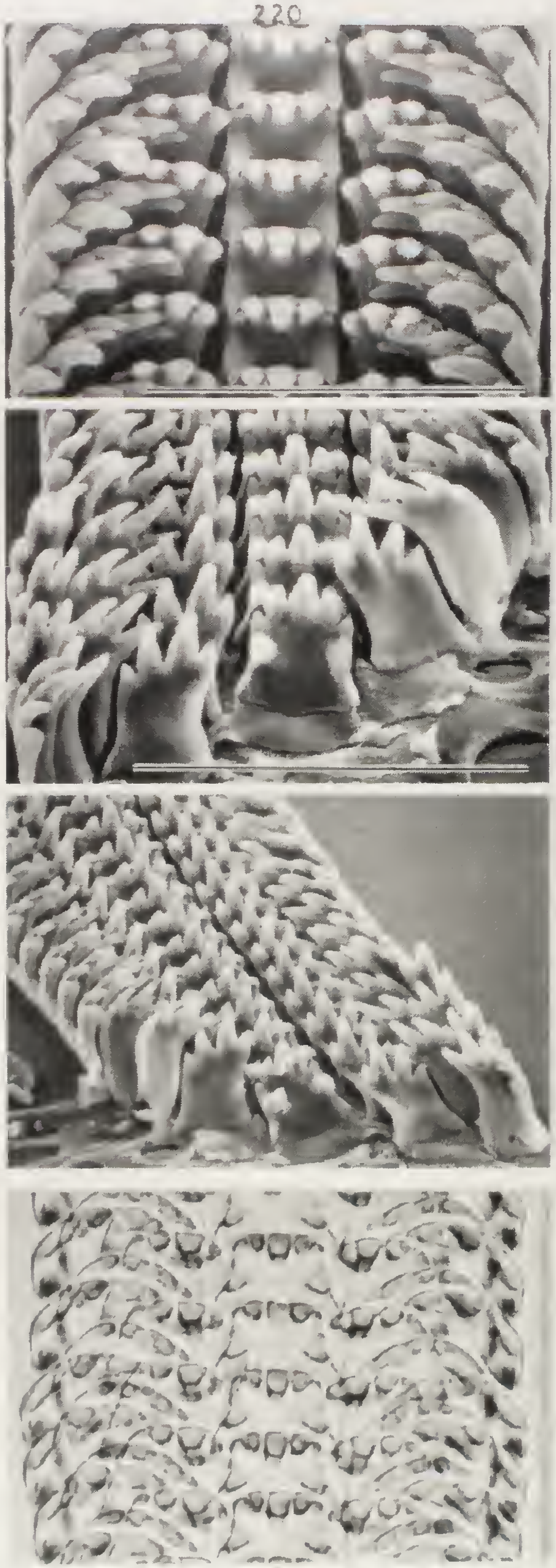


Figure 224. *Palmadusta ziczac*

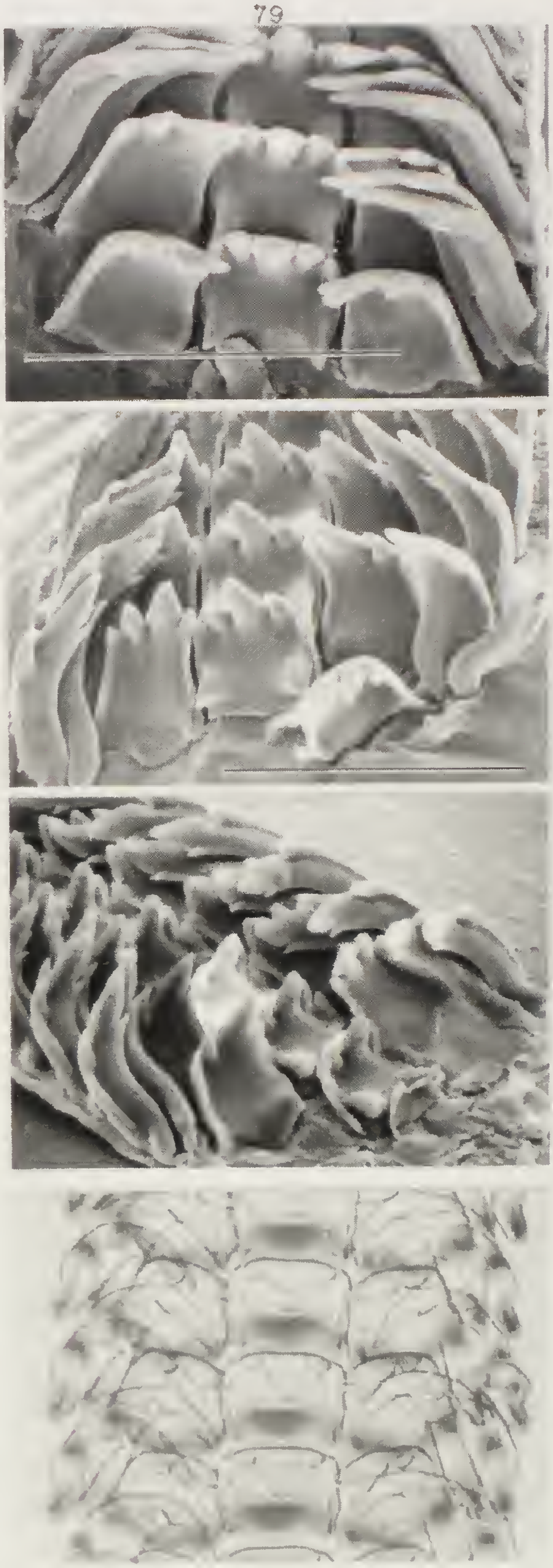


Figure 225. *Palmadusta fimbriata*

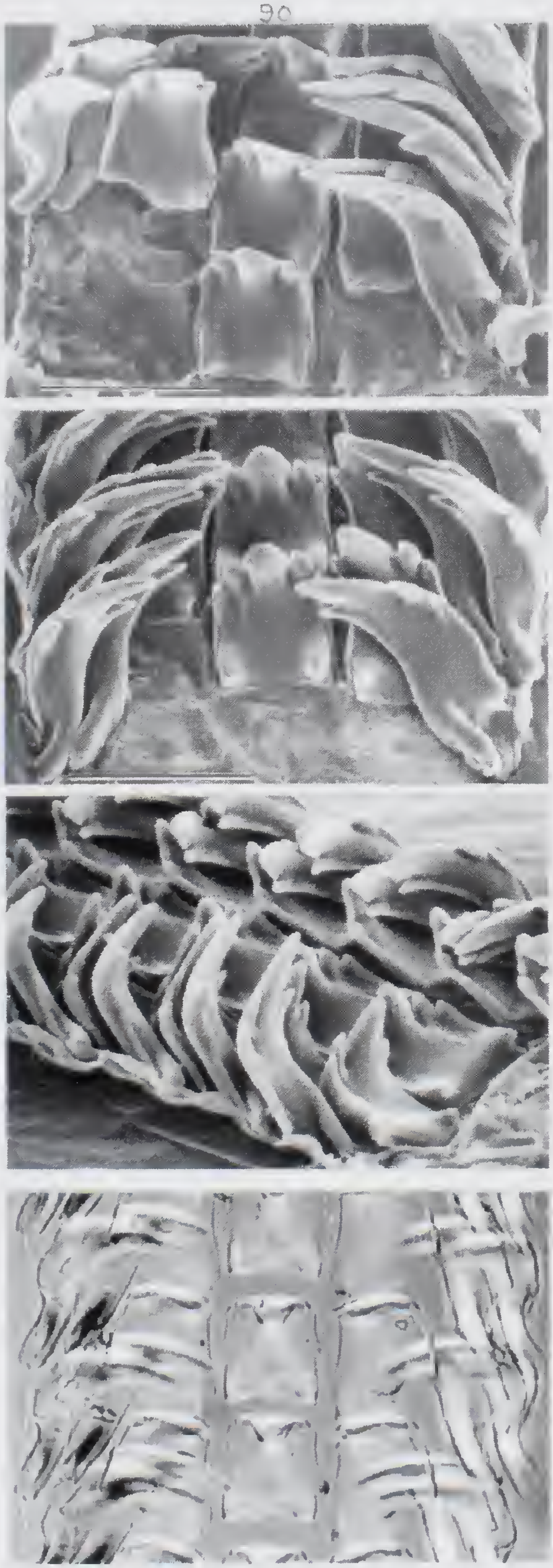


Figure 226. *Palmadusta gracilis*

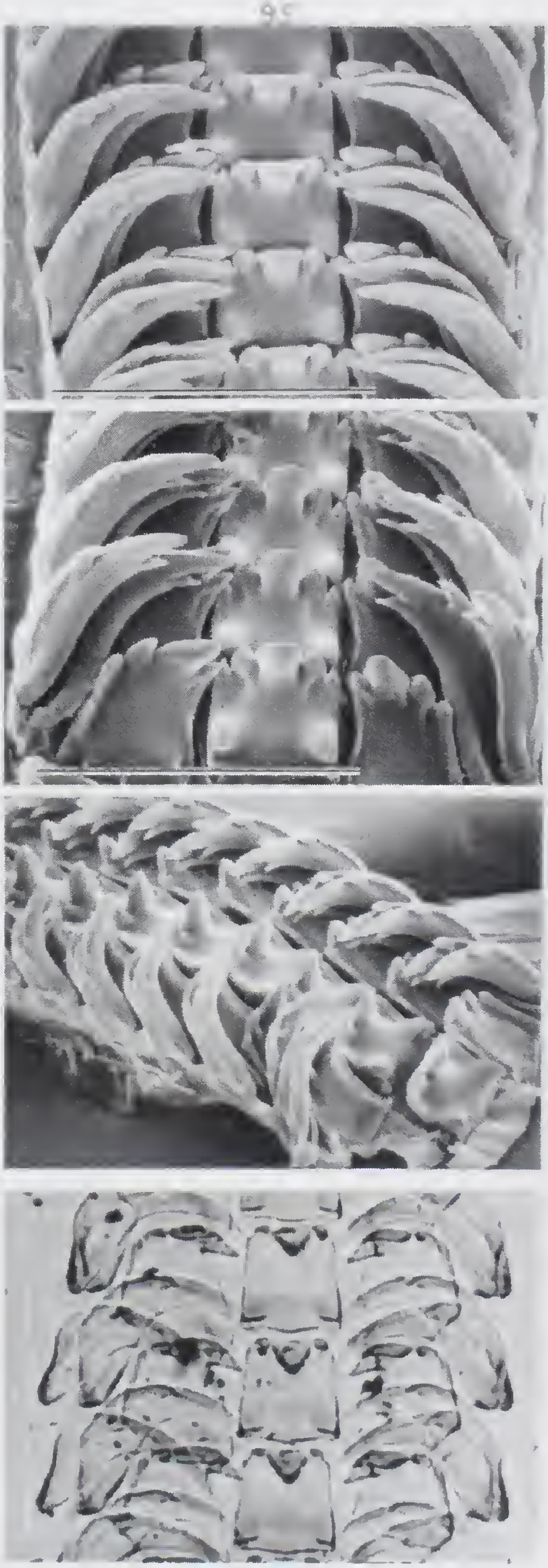


Figure 227. *Palmadusta hammondae*

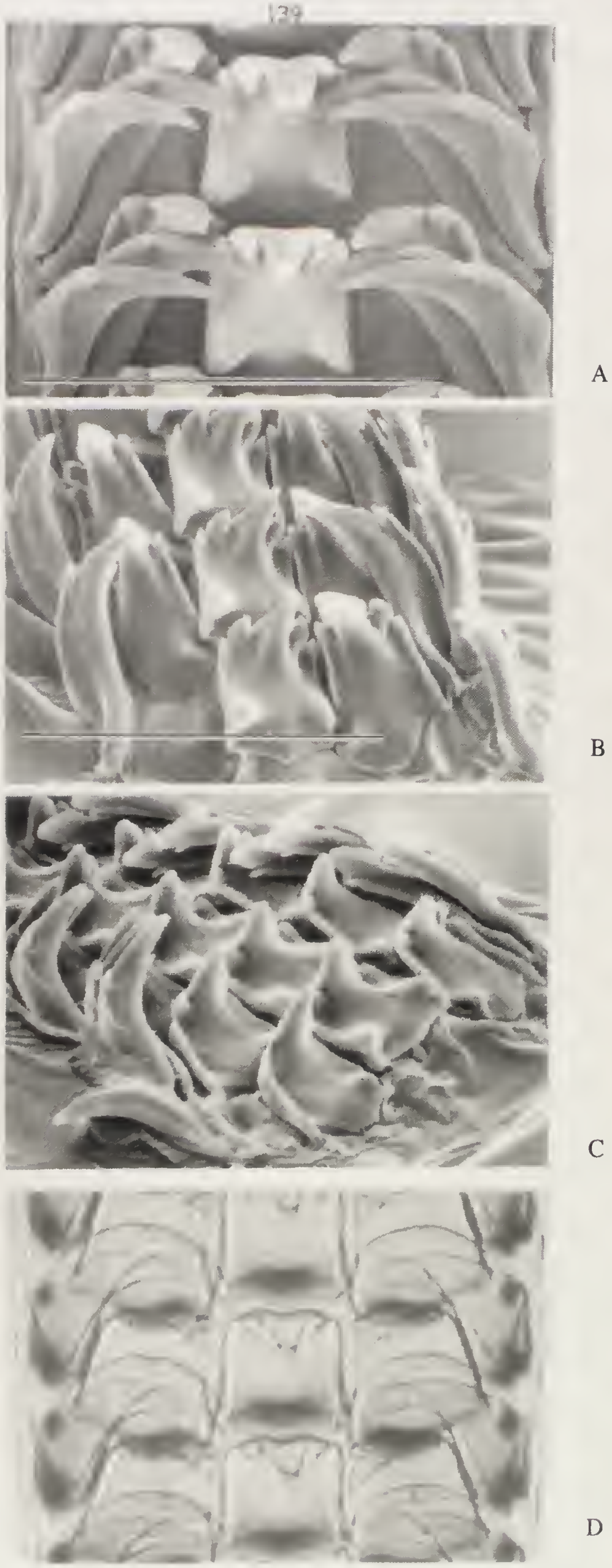


Figure 228. *Palmadusta microdon*

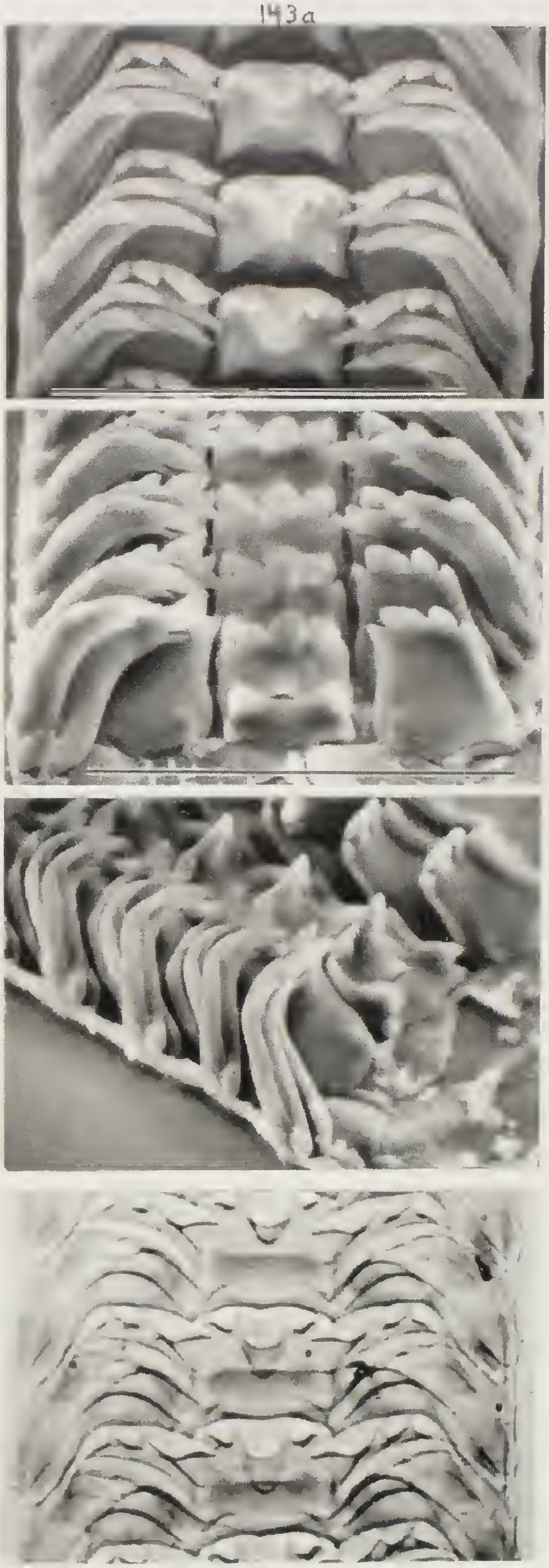


Figure 229. *Palmadusta minoridens*

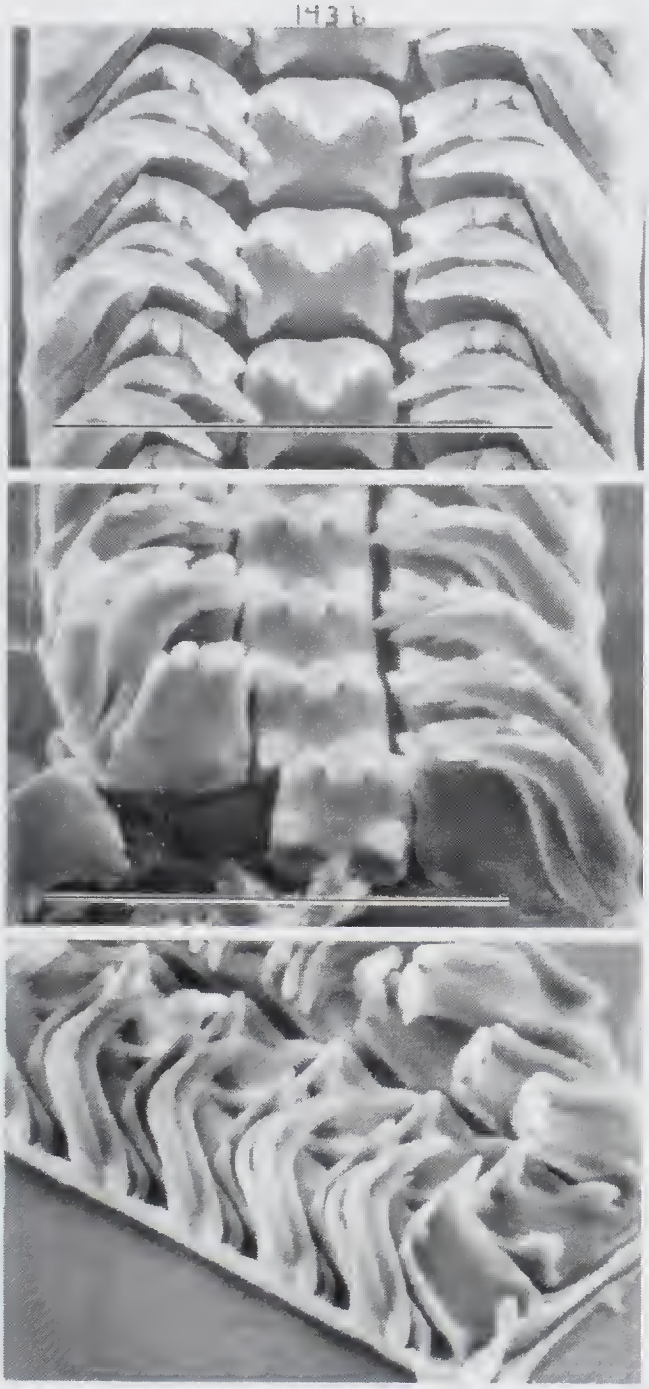


Figure 230. *Palmadusta minoridens*

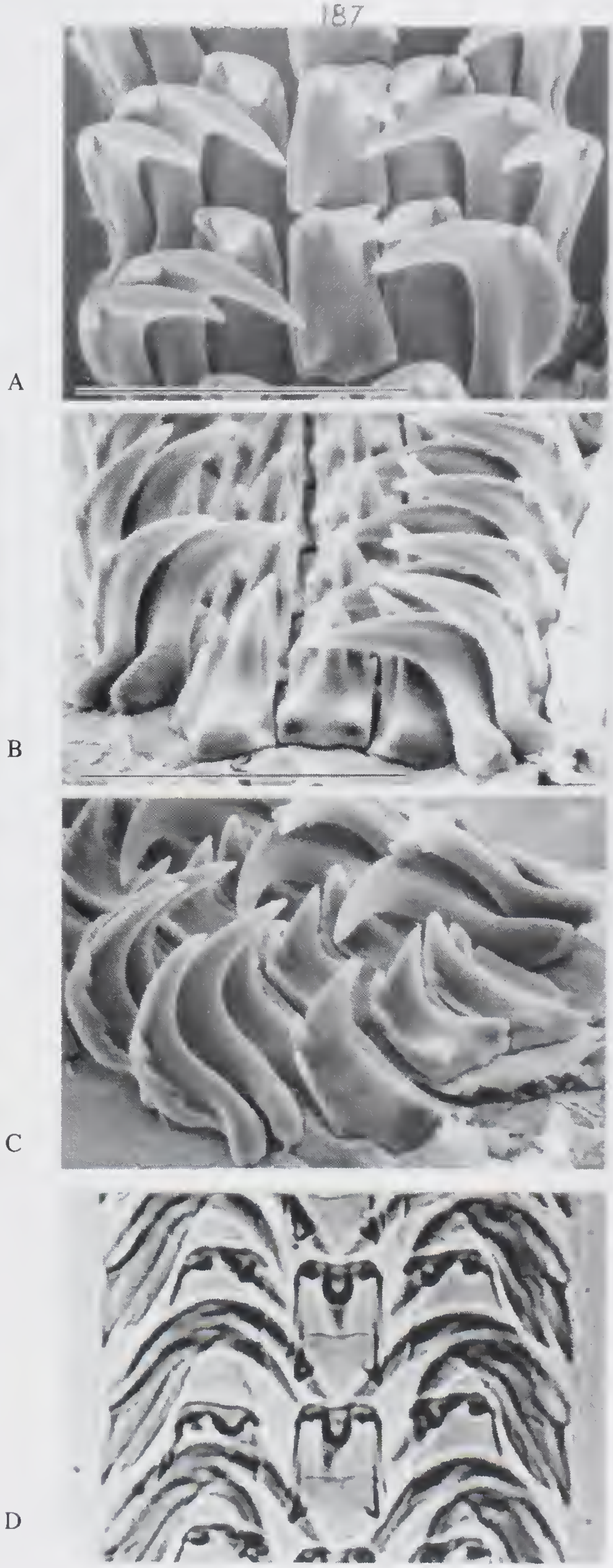


Figure 231. *Palmadusta serrulifera*

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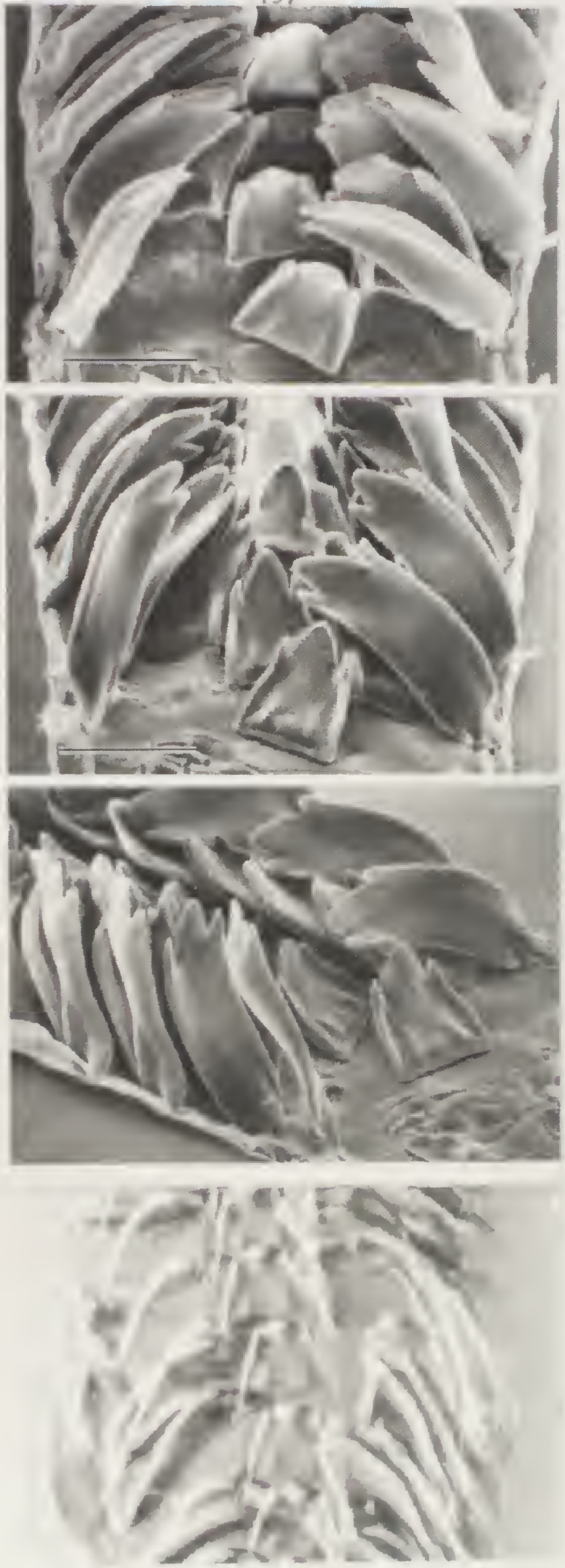

Figure 232. *Propustularia surinamensis*

~~129~~ 134

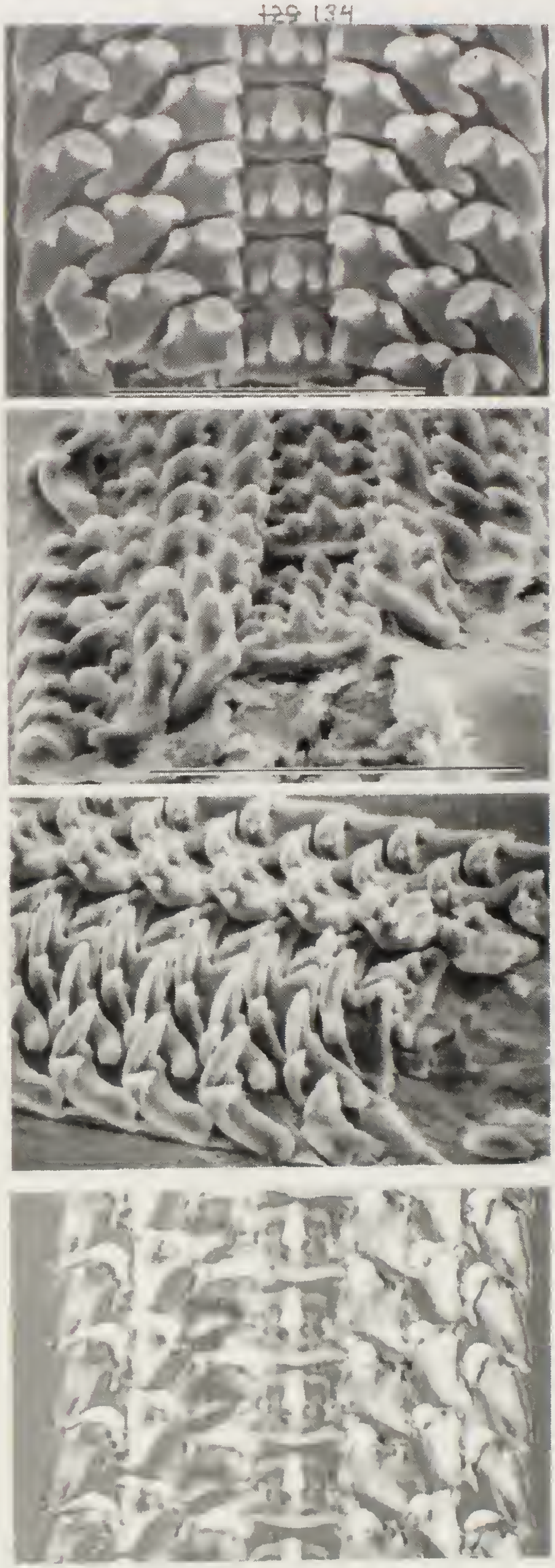

Figure 233. *Pustularia mariae*

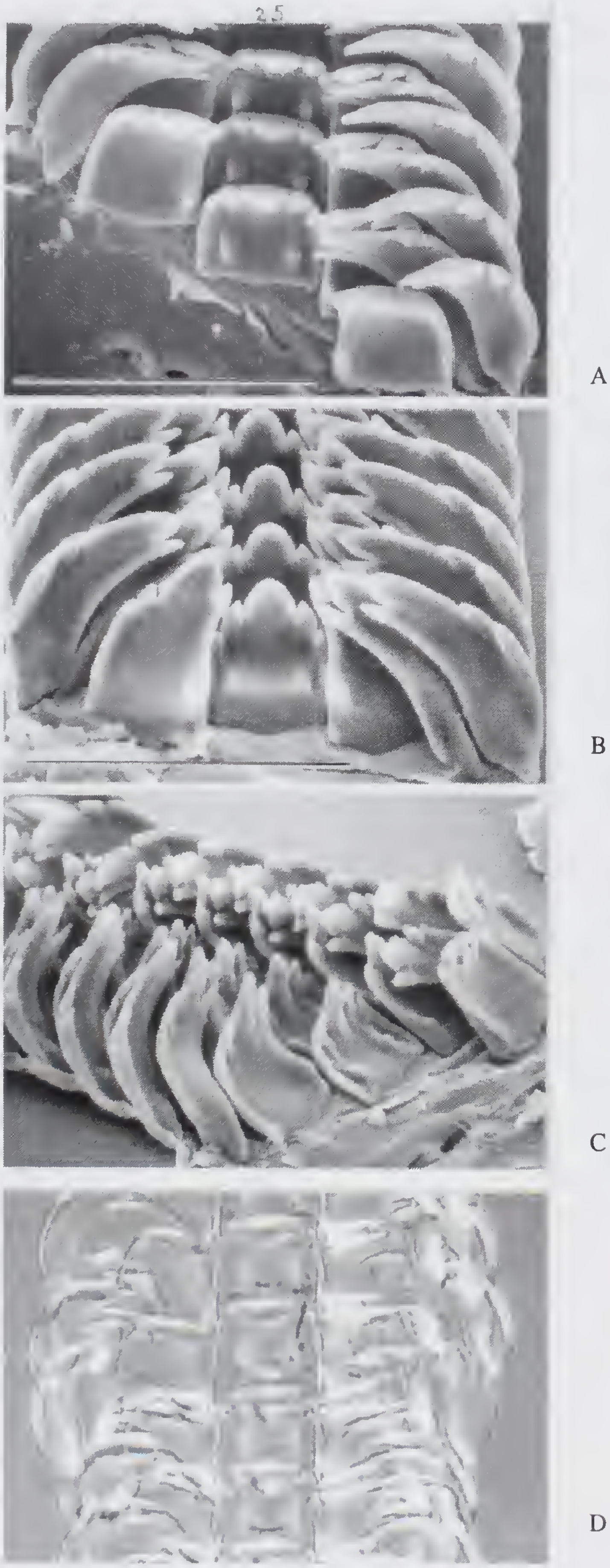

Figure 234. *Pustularia bistrinotata*

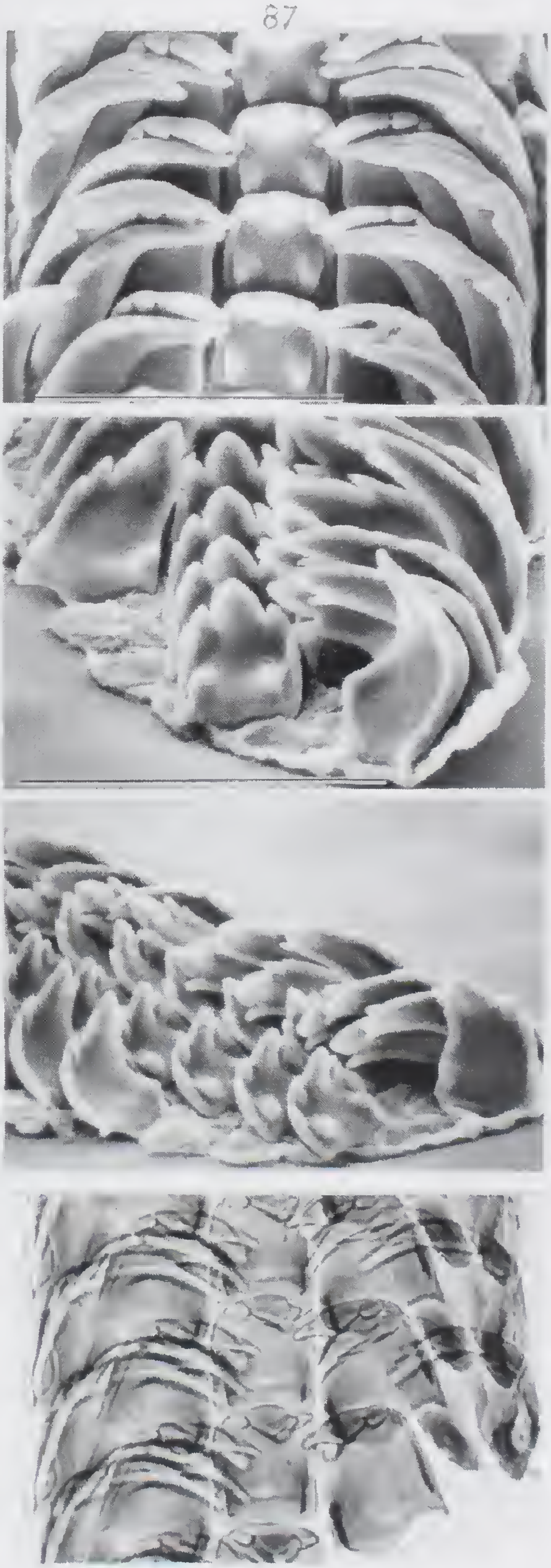

Figure 235. *Pustularia globulus*

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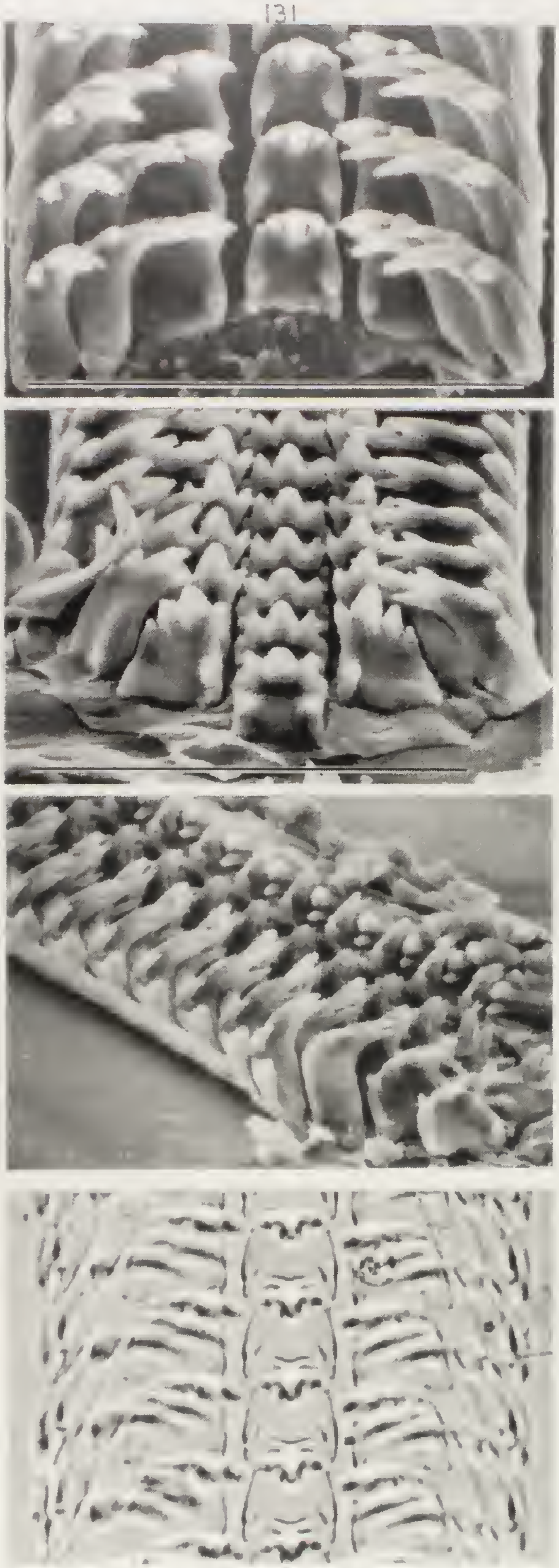


Figure 236. *Pustularia margarita*

136

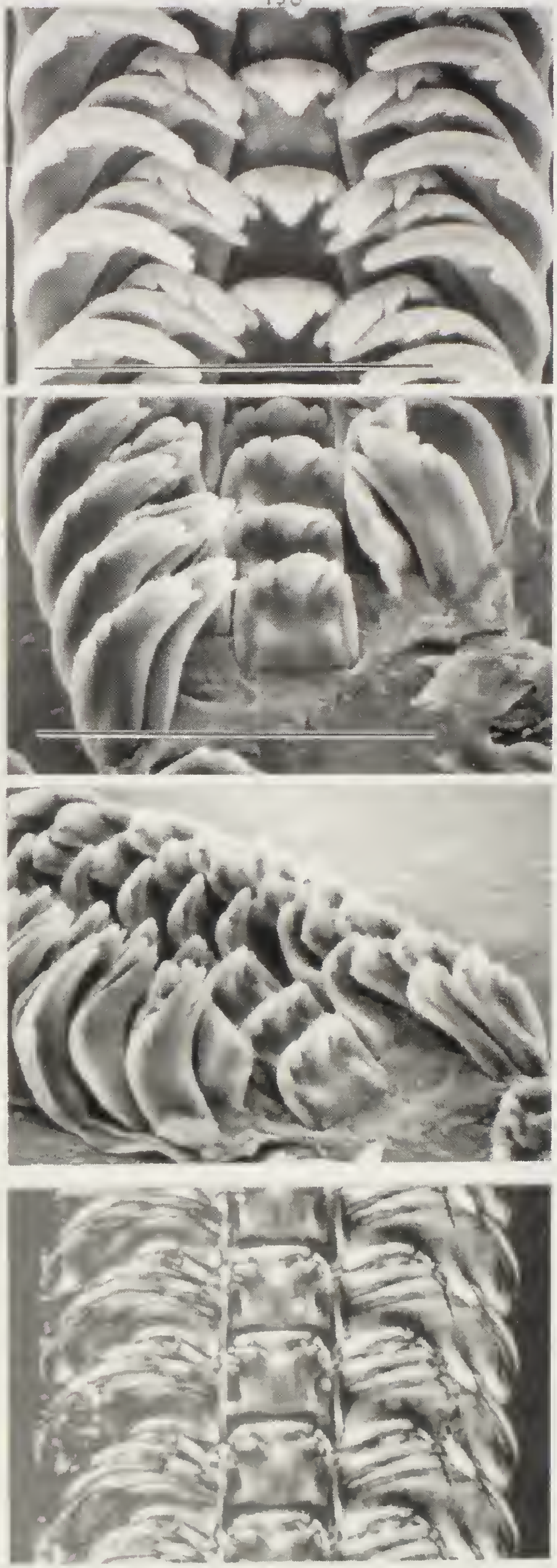
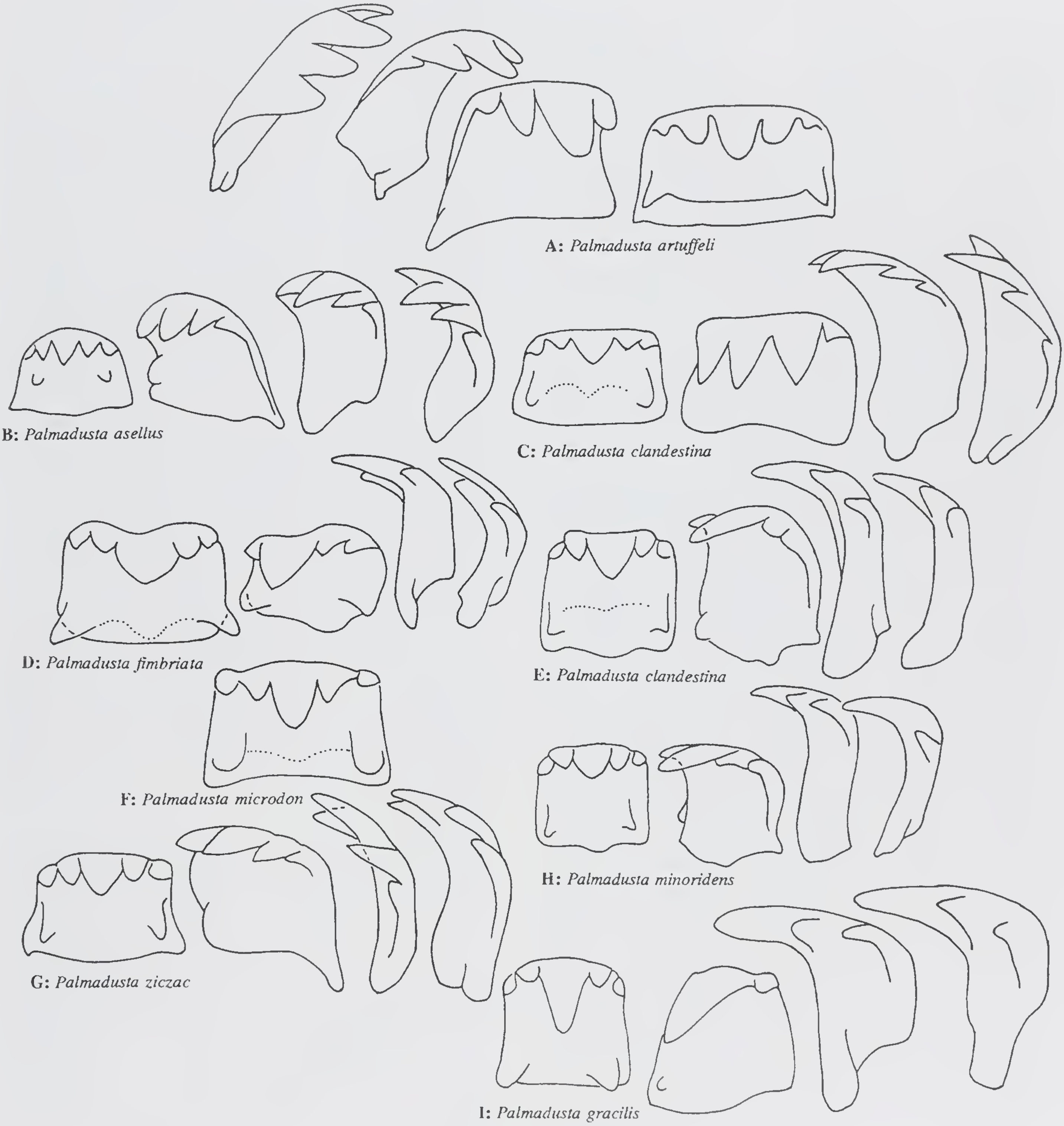


Figure 237. *Pustularia mauiensis*



A: *Palmadusta artuffeli*

B: *Palmadusta asellus*

C: *Palmadusta clandestina*

D: *Palmadusta fimbriata*

E: *Palmadusta clandestina*

F: *Palmadusta microdon*

G: *Palmadusta ziczac*

H: *Palmadusta minoridens*

I: *Palmadusta gracilis*

Figure 238. Cicercula pattern drawings

ACKNOWLEDGMENTS

Most of the common cowries for this study were collected by the authors, but the monograph would have limited coverage without the efforts of the many people who contributed specimens of live-collected cowries. Most significant were C. M. Burgess of Honolulu who made available his entire collection and Donald Pisor of San Diego who furnished more than 170 specimens including the rare *Nesiocypraea hirasei*, *Notocypraea katsuae*, *Lyncina leucodon*, and *Erronea lisetae*. James Tobin of Milwaukie, Oregon let us have his outstanding collection of 158 cowrie radula slides for optical microscopy. Masao Azuma of Japan allowed us to photograph his optical slide of *Nesiocypraea midwayensis*. Donald Bosch of Muscat-Oman furnished specimens of *Barycypraea teuleri* and *Erosaria marginalis*. Xavier Curvat of Nuku-Hiva, Marquises furnished a specimen of *Nucleolaria cassiaui*. Anthony D'Attilio, formerly of San Diego, furnished several specimens from the Islas Galápagos. Bruno de Bruin of Hout Bay, South Africa sent *Cypraeovula iutsui* and other rare South African specimens including a sinistral *Cypraeovula fuscorubra*. Billee Dilworth-Brown of La Jolla and her sister Twila Bratcher-Critchlow of Hollywood furnished specimens of nine species. We are indebted to members of the Hawaiian Malacological Society, especially to Chris Takahashi, Bob Dayle and Wesley Thorssen, for specimens of Hawaiian endemic species. Special thanks go to John Earle of Honolulu who furnished specimens of rare species from the Hawaiian Islands and Easter Island. Andrew Edinger of Esperance, Western Australia sent specimens including *Umbilia armeniaca* and *Zoila jeaniana*. Susanne Esparza of San Diego gave us an excellently cleaned radula from the *Lyncina aurantium* that she had collected on Kwajelein, Marshall Islands. Mike Hart of South Australia and New Zealand furnished specimens of *Cypraeovula capensis*, *C. coronata*, *C. mikeharti* and other African cowries. Gifts from Maurice Jay in La Réunion included the radula of *Lyncina broderipii*. Donald R. Shasky of Oceanside furnished 20 specimens including *Zonaria aequinoctialis*. Ruth Greenberg of the Tidepool Gallery in Malibu gave us 12 specimens including *Notadusta martini*. Among the San Diego Shell Club donors were Bob Yin who furnished 13 specimens including *Erosaria guttata* and *Nesiocypraea teramachii* and David K. Mulliner who furnished 11 specimens including an *Erronea onyx melanesiae* with a uniquely different radula. The following friends: Larry Buck, Greg Hamman, Jules & Carole Hertz, Linda & Kim Hutsell, and Ken & Marge Lindahl not only furnished specimens, but in addition helped establish contacts with potential sources. Walter O. Cernohorsky of New Zealand instructed the senior author in the skills of cowrie hunting in Fiji. David McLean gave a similar education in VaVa'u, Tonga. We acknowledge helpful discussions and advice from Terry Arnold and Hans Bertsch both of San Diego; Philippe Bouchet of Paris, France; Michel Boutet of Tahiti; Jean Cate of Rancho Santa Fe, California; Walter O. Cernohorsky of New Zealand; William K. Emerson of New York City; Terrence M. Gosliner of San Francisco; Maurice Jay of La Réunion and Helen Racz Lorenz of Montevideo, Uruguay. Professors Colin M. Bloor, Theodore H. Bullock, Ralph A. Lewin and Benjamin E. Volcani of UCSD and SIO gave helpful advice on techniques. We are particularly indebted to Annika Sanfilippo who gave counsel and the use of her own optical microscope for making hundreds of radula photos. Colin Bloor's Zeiss Axiomat microscope was used on some of the most difficult radula slides. Anne Dutton made several demonstration photos of Nomarski technique. We thank Kiyoteru Tokuyasu for the use of his scanning electron microscope and laboratory in the biology department of UCSD, and Regina Kawomoto for her SEM pictures taken at the SEM laboratory at the University of Hawaii at Manoa. Todd Price and Lance Washington were helpful in all aspects of the SEM and OM at UCSD. Science Applications Inc. in La Jolla furnished free SEM time during early stages of the investigation.

Specimens, advice and facilities were provided by staff at museums around the world, and especially to the junior author who was welcomed for weeks at a time at many institutions. We are grateful to the following for all their help and hospitality: The Academy of Natural Sciences, Philadelphia (David Robinson and Gary Rosenberg); American Museum of Natural History, New York (William K. Emerson and the late Walter Sage); The Australian Museum, Sydney (Ian Loch); California Academy of Sciences, San Francisco (Terrence M. Gosliner and William R. Liltved); Delaware Museum of Natural History (Albert Chadwick and Paula M. Mikkelsen); Department of Geology, Tulane University, New Orleans (Emily H. Vokes); Institut Royal des Sciences Naturelle de Belgique, Brussels (Jackie van Goethem and Annie Dondt); Museum für Naturkunde, Humboldt University, Berlin (Rudolph Kilias); Museum of

Paleontology, University of California, Berkeley (Carole S. Hickman and David R. Lindberg); National Museum of Natural History, Washington, D.C. (Warren Blow); The Natural History Museum, London (John Cooper, Noel Morris, Peter Morden, Joan Pickering, John Taylor and Kathie Way); Natural History Museum of Los Angeles County (Lindsey T. Groves and James H. McLean); Naturhistorisches Museum Basel (Peter Jung); Naturhistorisches Museum Wien, Austria (the late Erhard Wawra); Paleontological Research Institution, Ithaca (Peter Hoover); South Australian Museum, Adelaide (Karen Gowlett-Holmes); Western Australian Museum, Perth (Fred Wells); San Diego Natural History Museum (Thomas A. Deméré); Zoological Institute of St. Petersburg (Boris Sirenko); Zoologisk Museum, Copenhagen (Hopner Pedersen).

Reiney Adams and Peter Brueggeman, SIO Library, and Lindsey T. Groves, LACM, assisted in the literature search for Appendix III. The extensive scientific help of Lindsey T. Groves and James H. McLean significantly enhanced the manuscript. The painstaking task of editing and preparing the text for publication was carried out by Carole M. and Jules Hertz. Suzanne Parlett designed the cover. Marge Bradner assisted us with research, proofreading and secretarial efforts. Photographs for publication were printed by David K. Mulliner, then scanned and converted to PageMaker files by the senior author with the assistance of Amy Soukup. We are indebted to Paul H. Scott, Santa Barbara Museum of Natural History and to DeepSea Power and Light Company in San Diego, for instruction and use of desktop publishing facilities.

Inevitably we may have failed to include some important contributors in these acknowledgments. More nearly complete records can be found in the notebooks and tabulations that will be deposited in The Natural History Museum, London.

The work of the senior author was supported by grants from the Foundation For Ocean Research, the Director of Scripps Institution of Oceanography and the Academic Senate of the University of California, San Diego. The work of the junior author was supported by the Zoology Department, University of Hawaii at Manoa and by contracts with the City and County of Honolulu. Publication was supported by DeepSea Power and Light and grants from Scripps Institution of Oceanography and the San Diego Shell Club.

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APPENDIX I. CYPRAEA RADULAE ILLUSTRATED IN THIS MONOGRAPH

The first column shows species identification numbers (ID) which accompanied the photos at all stages of the study and appear as hand-written numbers at the top of the photo strips. The species are listed in the second column. The third column shows the figure number corresponding to the SEM and OM radula photos in this monograph. Columns A, B and C refer to SEM stubs. Column D refers to OM slides. SEM specimens on conical stubs are designated by >, for example the A view of *Notadusta katsuae* is from conical stub >51. The other SEM stubs are designated by lower case letter+number, for example *Notadusta angustata* w1 or *Schilderia achatidea* η10. Microscope slides are identified by number+upper case letter, where the letter indicates the donor of the slide.

ID	Species	Figure	A	B	C	D
001	*Schilderia achatidea*	154	η10	η10	η10	186B
002	*Zonaria aequinoctialis*	119	θ5	θ5	θ5	1T
003	*Erosaria albuginosa*	31	ζ8	ζ8	ζ8	19B
004	*Cypraeovula alfredensis*	157	v3	v3	v3	83B
005	*Cypraeovula algoensis*	158	v10	v10	v10	3T
006	*Blasicrura alisonae*	64	ν9	ν9	ν9	217B
009	*Notcypraea angustata*	208	w1	w1	w1	153K
010	*Zonaria annettae*	120	v6	v6	v6	1K
011	*Monetaria annulus*	57	n12	n12	n12	41T2
012	*Mauritia arabica*	107	f7	f7	f7	5K
013	*Mauritia arabicula*	108	β8	β8	β8	6K
014	*Lyncina argus*	12	ζ1	η2	ζ1	8K
015	*Umbilia armeniaca*	138	γ9	γ9	γ9	52B
016	*Palmadusta artuffeli*	216	θ11	θ11	θ11	197B
017	*Palmadusta asellus*	217	d1	d1	d1	9T
018	*Cribrarula astaryi*	198	p10	p10	p10	23B
019	*Lyncina aurantium*	13	g5	g5	g5	10T
021	*Erronea barclayi*	87	δ11	δ11	δ11	61B
022	*Erosaria beckii*	50	q1	q1	q1	13T
024	*Notocypraea bicolor*	209	u9	u9	u9	194B

025	*Pustularia bistrinotata*	234	η5	η5	η5	180B
026	*Erosaria boivinii*		32	z7	z7	z7
027	*Lyncina bouteti*	14	θ12	θ12	θ12	198B
028	*Erronea bregeriana*	88	x9	x9	x9	27B
029	*Lyncina broderipii*	15	z12	z12	z12	56B
030	*Blasicrura burgessi*	65	ν6	ν6	ν6	215B
031	*Lyncina camelopardalis*	16	ν10	ν10	ν10	219B
032	*Cypraeovula capensis*	159	v4	v4	v4	30B
033	*Erosaria caputdraconis*	54	r7	r7	r7	45T2
035	*Erosaria caputserpentis*	55	s8	g7	s8	14T
036	*Lyncina carneola*	17	ζ4	ζ4	ζ4	145K
037	*Nucleolaria cassiaui*	186	β10	β10	β10	31B
038	*Cribrarula catholicorum*	199	y8	y8	y8	32B
039	*Erronea caurica*	83	r1	r1	r1	18T
040	*Erosaria cernica*		33	t1	t1	t1
041	*Macrocypraea cervinetta*	115	θ8	θ8	θ8	193B
042	*Macrocypraea cervus*	116	u8	u8	u8	237B
043	*Pustularia childreni*	60	y5	y5	y5	37B
044	*Ovatipsa chinensis*	76	t4	t4	t4	36T2
045	*Pustularia cicercula*	196	x8	x8	x8	38K
046	*Luria cinerea*	149	w12	w12	w12	61K
047	*Erosaria citrina*	34	α9	α9	α9	38B
048	*Palmadusta clandestina*	218	η3	m4	η3	16T2
050	*Ovatipsa coloba*	77	α10	α10	α10	39B
051	*Notocypraea comptonii*	210	γ12	γ12	γ12	30T
052	*Cypraeovula connelli*	160	δ8	δ8	δ8	58B
053	*Palmadusta contaminata*	219	k8	k8	k8	31T
054	*Cypraeovula coronata*	161	w4	w4	w4	40B
055	*Blasicrura coxeni*	79	α1	α1	α1	178B

056	*Cribrarula cribellum*	200	j12	j12	j12	36B
057	*Cribrarula cribraria*	201	m6	h12	m6	52T2
059	*Cypraeovula cruickshanki*	162	μ4	μ4	μ4	33T
060	*Cribrarula cumingii*	202	i4	i4	i4	120B
061	*Erronea cylindrica*	84	i5	i5	i5	35T
062	*Blasicrura dayritiana*	80	η8	η8	η8	184B
063	*Zoila decipiens*	140	β1	β1	β1	139B
064	*Notocypraea declivis*	211	γ6	γ7	γ6	36T
065	*Mauritia depressa*	109	s6	s6	s6	44B
066	*Erosaria dillwyni*	51	z2	z2	z2	41B
067	*Palmadusta diluculum*	220	ϵ6	ϵ6	ϵ6	142B
068	*Erosaria eburnea*	35	h3	h3	h3	40T
069	*Cypraeovula edentula*	163	v7	v7	v7	245B
070	*Mauritia eglantina*	110	μ10	μ10	μ10	46T2
071	*Erosaria englerti*	36	s1	s1	s1	47T2
072	*Erosaria erosa*	30	t5	t5	t5	54T2
073	*Erronea errones*	78	n4	n4	>50	91K
074	*Bistolida erythraeensis*	71	o6	o6	o6	156B
075a	*Cribrarula esontropia*	203	ξ2	ξ2	ξ2	201B
075b	*Cribrarula esontropia*	204	ξ4	ξ4	ξ4	----
075c	*Cribrarula esontropia*	205	x5	x5	x5	----
076	*Talparia exusta*	178	λ12	λ12	λ12	45T
077	*Cribrarula fallax*	206	z10	z10	z10	----
078	*Erronea felina*	85	l12	l12	l12	157B
079	*Palmadusta (Purpuradusta) fimbriata*	225	h5	h5	l11	49T
080	*Zoila friendii*	141	γ10	γ10	γ10	120K
081	*Barycypraea fultoni*	155	δ9	δ9	δ9	51T
082	*Cypraeovula fuscodentata*	164	w5	w5	w5	78B
083	*Cypraeovula fuscorubra*	165	v12	v12	v12	243B

084	*Zonaria gambiensis*	121	ν1	ν1	ν1	13O
085	*Erosaria gangranosa*	37	z9	z9	z9	15B
086	*Cribrarula gaskoini*	207	e9	e9	e9	52T
087	*Pustularia globulus*	235	v2	v2	v2	63K
088	*Cypraeovula gondwanalandensis*	166	y11	y11	y11	86B
089	*Blasicrura goodallii*	183	s3	s3	s3	224B
090	*Palmadusta (Purpuradusta) gracilis*	226	e10	e10	e10	174B
091	*Nucleolaria granulata*	187	λ9	λ9	λ9	56T
092	*Mauritia grayana*	111	μ11	μ11	μ11	75B
093	*Erosaria guttata*	38	p7	p7	p7	76B
095	*Palmadusta (Purpuradusta) hammondae*	227	>61	>61	t9	67K
096	*Erosaria helvola*	39	g1	i9	g1	48T2
097	*Umbilia hesitata*	139	γ8	γ8	γ8	59T
098	*Nesiocypraea hirasei*	169	ν2	ν2	ν2	#aK
099	*Bistolida hirundo*	72	r10	r10	r10	155B
100	*Mauritia histrio*	112	ν5	ν5	ν5	61T
102	*Erronea hungerfordi*	89	u12	u12	u12	233B
103	*Blasicrura interrupta*	197	ϵ5	ϵ5	ϵ5	141B
104	*Naria irrorata*	59	h9	h9	h9	175B
105	*Luria isabella*	147	q10	q10	q10	63T
106	*Luria isabellamexicana*	148	w3	p11	p11	65T
107	*Cypraeovula iutsui*	167	ξ8	ξ8	ξ8	136B
108	*Zoila jeaniana*	142	γ5	γ5	γ5	46B
110	*Notadusta katsuae*	99	>51	t8	t8	----
111	*Bistolida kieneri*	73	r11	r11	r11	66T
112	*Erosaria kingae*	40	z11	z11	z11	87B
113	*Lyncina kuroharai*	18	y4	y4	y4	118B
114	*Erosaria labrolineata*	41	m2	e12	m2	67T
115	*Erosaria lamarckii*	42	γ4	γ4	γ4	68T

116	*Nesiocypraea langfordi*	170	λ10	λ10	λ10	69T
226	*Blasicrura latior*	66	ν7	ν7	ν7	216B
117	*Palmadusta lentiginosa*	221	o2	o2	o2	3O
118	*Lyncina leucodon*	19	c2	g10	c2	119B
119	*Lyncina leviathan*	20	w10	p9	w10	26K
120	*Staphylaea limacina*	182	n6	n6	n6	70T
121	*Erronea lisetae*	90	ξ10-12; π1-7		---	----
123	*Blasicrura luchuana*	81	ζ6	ζ6	ζ6	115B
124	*Luria lurida*	150	u5	k5	u5	71T
125	*Palmadusta lutea*	222	z3	z3	z3	133B
126	*Lyncina lynx*	11	q8	q8	q8	83K
127	*Erosaria macandrewi*	52	y12	y12	y12	207B
128	*Mauritia maculifera*	113	q4	q4	q4	235B
130	*Cypraea mappa*	134	l8	l8	l8	87K
131	*Pustularia margarita*	236	μ5	o11	o11	211B
132	*Erosaria marginalis*	43	δ5	δ5	δ5	76T
133	*Zoila marginata*	143	l10	l10	l10	77T
134	*Pustularia mariae*	233	η4	v1	η4	179B
135	*Notadusta martini*	100	k7	k7	k7	43T2
136	*Pustularia mauiensis*	237	r9	r9	r9	210B
137	*Mauritia mauritiana*	106	r6	r6	r6	80T
138	*Notocypraea mayi*	212	v9	v9	v9	102B
139	*Palmadusta (Purpuradusta) microdon*	228	i6	i6	i6	82T
140	*Nesiocypraea midwayensis*	171	---	---	---	1A
141	*Cypraeovula mikeharti*	168	w2	w2	w2	100B
142	*Erosaria miliaris*	44	γ11	γ11	γ11	89K
143a	*Palmadusta (Purpuradusta) minoridens*	229	ε11	ε11	ε11	128B
143b	*Palmadusta (Purpuradusta) minoridens*	230	m1	m1	m1	----
144	*Monetaria moneta*	56	r3	>52	r3	84T

145	*Muracypraea mus*	137	x4	x4	x4	114B
147	*Erosaria nebrites*	45	z4	α4	z4	72B
148	*Zonaria nigropunctata*	129	t10	t10	t10	145B
149	*Lyncina nivosa*	21	v11	v11	v11	112B
150	*Nucleolaria nucleus*	188	l1	l1	l1	57T2
151	*Monetaria obvelata*	58	f12	i12	i12	227B
152	*Erosaria ocellata*	46	δ4	δ4	δ4	74B
153	*Erronea onyx*	91	p6	p6	p6	87B
155	*Erronea ovum*	86	p4	p4	p4	177B
156	*Bistolida owenii*	74	λ5	λ5	λ5	88T
157	*Erronea pallida*	92	ν4	ν4	ν4	137B
158	*Blasicrura pallidula*	184	α6	α6	α6	205B
159	*Cypraea pantherina*	135	λ3	λ3	λ3	90T
160	*Zonaria petitiana*	122	y1	y1	y1	241B
161	*Zonaria picta*	123	λ11	λ11	λ11	91T
162	*Notocypraea piperita*	213	x1	x1	x1	111B
163	*Erosaria poraria*	47	g6	g6	g9	92B
165	*Lyncina propinqua*	22	d3	d3	d3	121B
166	*Erronea pulchella*	93	ξ9	ξ9	ξ9	247B
167	*Luria pulchra*	151	q3	q3	q3	93T
168	*Notocypraea pulicaria*	214	ζ12	ζ12	ζ12	165B
169a	*Notadusta punctata*	101	i3	i3	m3	94T
169b	*Notadusta punctata*	102	---	o8	---	----
170	*Erronea pyriformis*	94	α5	α5	α5	96K
171	*Zonaria pyrum*	124	λ4	λ4	λ4	89T
172	*Blasicrura quadrimaculata*	82	p3	p3	p3	135B
173	*Notadusta rabaulensis*	103	α12	α12	α12	110B
174	*Blasicrura rashleighana*	67	e8	e8	e8	127K
176	*Lyncina reevei*	23	β5	β5	β5	98K

177	*Zonaria robertsi*	125	θ10	θ10	θ10	95T
178	*Zoila rosselli*	144	k2	k2	k2	18T2
179	*Nesiocypraea sakuraii*	172	y9	y9	y9	107B
180	*Zonaria sanguinolenta*	126	x12	x12	x12	96T
181	*Palmadusta saulae*	223	r4	r4	h11	93B
183	*Lyncina schilderorum*	24	w6	w6	w11	34A
184	hybrid *schilderorum/sulcidentata*	26	η1	η1	η1	64B
185	*Mauritia scurra*	114	n7	n7	n7	97T
186a	*Staphylaea semiplota*	190	j5 (specimen No. 1)			105K
186b	*Staphylaea semiplota*	191	j5 (specimen No. 2)			----
186c	*Staphylaea semiplota annae*	192	j6	j6	j6	----
187	*Palmadusta (Purpuradusta) serrulifera*	231	o7	o7	o7	176B
188	*Zonaria spadicea*	128	t7	j3	s10	98T
189	*Erosaria spurca*	48	x7	x7	x7	1T2
190a	*Staphylaea staphylaea*	193	m11 (specimen No. 2)			109K
190b	*Staphylaea staphylaea*	194	m11 (specimen No. 1)			----
191	*Trona stercoraria*	118	z5	z5	z5	2T2
192	*Bistolida stolida*	70	e11	e11	n2	3T2
193	*Blasicrura subteres*	68	y7	y7	y7	105B
194	*Erronea subviridis*	95	w8	w8	w8	181B
195	*Lyncina sulcidentata*	25	l7	l7	l7	3T2
196	*Blasicrura summersi*	185	n5	n5	n5	127B
197	*Propustularia surinamensis*	232	λ2	λ2	λ2	199B
198a	*Talparia talpa*	177	n3	p12	p12	6T2
198b	*Talparia talpa*	176	n3 (Marginal teeth)			----
199	*Nesiocypraea teramachii*	173	g12	g12	g12	91B
200	*Blasicrura teres*	63	q7	q7	q7	9T2
201	*Luria tessellata*	152	z6	z6	z6	13T2
202a	*Chelycypraea testudinaria*	180	x6	x6	x6	119K

202b	*Chelycypraea testudinaria*	179	x6 (Detail of teeth)			----
203	*Barycypraea teulerei*	156	r8	r8	r8	132B
204	*Erosaria thomasi*	53	ξ3	ξ3	ξ3	222B
205a	*Cypraea tigris*	132	m9	m9	m9	48T
205b	*Cypraea tigris schilderiana*	133	l9	l9	l9	13B
206	*Notocypraea trenberthae*	215	x2	x2	x2	209B
207	*Erosaria turdus*	49	ζ2	ζ2	ζ2	130K
208	*Bistolida ursellus*	75	r12	r12	r12	123B
209	*Cypraea valentia*	136	ϵ8	ϵ8	ϵ8	144B
210	*Lyncina ventriculus*	27	y2	y2	y2	90B
211	*Zoila venusta*	145	l6	l6	l6	20T2
213	*Lyncina vitellus*	28	m7	m7	t6	26T2
215	*Erronea vredenburgi*	96	ν3	ν3	ν3	16O
216	*Erronea walkeri*	97	t3	t3	t3	239B
217	*Erronea xanthodon*	98	η7	o4	o4	182B
218	*Palmadusta yaloka*	189	j10	j10	j10	169B
219	*Macrocypraea zebra*	117	l4	l4	l4	144K
220	*Palmadusta ziczac*	224	r2	r2	r2	30T2
221	*Zonaria zonaria*	127	x10	x10	x10	8O

APPENDIX II. SHELL AND RADULA DATA

SEM specimens are designated by lower case letter+number, for example *chinensis* t4 or *barclayi* δ11. SEM specimens on conical stubs are designated by >, for example *hammondae* >61. Microscope slides are designated by number+upper case letter, for example 160K, where the letter indicates the donor of the slide. Vials are designated by upper case letter V:+number, eg. V:364. In some cases, such as in *beckii*, more than one specimen of a species was mounted on the same stub. These specimens are listed as sp. 1, sp. 2 etc.

Shell length and radula length are shown in mm. Central tooth length and width are shown in microns. In some patterns the average numbers and the range of dimensions are drawn from a larger population than shown in this table. "Reasonable judgment" has been used in rounding numbers to appropriate significant digits. For example, measured values for central tooth dimensions of *aequinoctialis* were:

θ5 : Length = 209 microns. Width = 135 microns. G3 : Length = 208 microns. Width = 133 microns.

Species	**No.**	**Shell length**	**Radula length**	**Rows per mm**	**No. of rows**	**Central tooth length**	**width**
achatidea	η10	39	15	3.8		280	210
	θ7					230	210
	λ8			4.7			
aequinoctialis	θ5			5.9		210	135
	g3	39	19	7.3	160	210	135
	k11	39	18	8.3	130	220	160
albuginosa	ζ8			11.2		95	75
	-	16	8				
	-	17	9.5				
	-	18	10.2				
	-	19	11				
	-	19	11				
	-	20	13				
	-	19	9.5				
	-	18	8.5				
	-	16	8.5				
alfredensis	v3			10.3		105	95
	v8			9.1		125	95
algoensis	v10		12	7.7	95	130	110
alisonae	ν8	28	15	4.7	70	170	200
	ν9					115	130
	u1	30	7	10.4	73		
	u2	31	6	10.2	61		
	β2	41	7	11.8	80		
	β3	38	5	14.7	75		
	t2			9.5			
	V:364	30	8				
	-	35	20				
	-	35	18				

angustata	w1			7		160	160
annettae	v6			3.6		225	175
	g2	40	23.5				
	g2	41	25				
	g4						180
	β9						125
annulus	n12			10.6		105	90
	k9						80
	c12						100
arabica	f7			6.6		200	140
arabicula	β8			6.6		170	105
argus	ζ1	55	52	5.1	265		
	ζ1	66	52	5.4	285	190	240
	η2			6.2		170	230
armeniaca	γ9		46	2.6	120	430	365
	-	89	32				
artuffeli	θ11	18	4	24.1	95	65	60
asellus	d1			20.4		55	50
	160B	17	5	24	120		
astaryi	p10	18	9	18.5	165	80	65
aurantium	g5		76	4	305	261	430
barclayi	δ11			6.6		150	95
	y10			7		150	105
beckii sp.1	q1	16	12	10.3	130	100	80
sp.2	q1			11.2		70	60
sp.1	ϵ9			13.9			45
sp.2	ϵ9						60
sp.3	ϵ9						65
bicolor	u9					95	90
bistrinotata	η5	17	7.5	20.5		70	60
	g11			30.4		50	45
	180B	15	4.8				
	-	15	5				
	-	14	4.5				
boivinii	z7	28	14.5	9.7	140	105	90
	-	25	12				
	-	24	14				
bouteti	θ12			6.7		180	195

bregeriana	x9			11		110	95
broderipii	z12			4.3		225	305
	δ6			4			300
burgessi	v6			6.2		150	160
camelopardalis	v10	67	38	8	305	160	220
capensis	v4			5.5		185	105
caputdraconis	r7			7.8		130	110
caputserpentis	k1			7.9		135	135
	s8			6.3			150
carneola	l2			10.5		100	140
	ζ4			9		105	160
	ζ9	48	38	7	265	140	200
	ζ3			14		80	125
	β11			15		80	110
	-	23	17.5				
cassiaui	β10	28	10	16.7	165	100	95
catholicorum	y8			22.4		70	40
caurica	r1			6.9		155	140
cernica	t1	20	10	9.5	95	105	90
	u11			12.1		75	60
(Easter Is.)	s2	33	14	5.5	75	175	145
" sp. 1	α8	26	15	7.7	115	95	75
" sp. 2	α8	21	11	12.7	140		
cervinetta	θ8			4.4		170	100
cervus	u8			3.3		305	205
childreni	y5			13.9		115	50
chinensis	t4			6.4		155	155
(Hawaii)	187B	38	20				
cicercula	x8		8	20	160	65	30
	μ5	13	6			45	30
	μ8	15	6.5				
cinerea	w12			5.9		230	150
sp.1	x3	32	22	5.4	120	225	225
sp.2	x3			8.6		190	160
citrina	α9			6.1		150	140

clandestina	η3	18	5	23	110	65	75
sp.1	m4			31		50	45
sp.2	m4			32			
coloba	α10		10			110	120
	α11	24	10.5	13.6			
comptonii	γ12	21	8	13.4	105	110	95
	x2	20	8.5	14.5	120		
	209B	21	9.5				
connelli	δ8			7.7		160	115
contaminata	k8			23.5		55	50
	ν11			40.5		40	30
	-	14	6.5				
	-	8	2.5				
coronata	w4		17	5.3		170	155
coxeni	α1			17.9		100	100
	178B	19	6.5				
cribellum	j12			23.7		65	35
	-	16	6				
cribraria	m6	17	7	18.5	125	60	40
cribraria comma	ε4					45	45
cruickshanki	*δ10*			6		185	120
	μ3			4		240	190
	μ4					240	170
cumingii	i4			39.1		30	25
cylindrica	*i5*			7.7		145	100
	173B	28	12				
dayritiana	η8	17	12			85	50
	-	17	12				
	-	17	11				
	184B	17	10				
decipiens	β1		26	4.6		220	205
decipiens perlae [eludens?]	ε3	66	32	4		240	255
declivis	γ6	23	17	8.6	145	175	120
	γ7	23	15				
depressa	s6			5.5		195	140
dillwyni	z2			19		50	45

diluculum	ϵ6	24	7	16.4	115	70	85
	-	23	6				
	-	24	6				
eburnea	h3			10		120	140
edentula	v7			9.7		100	90
eglantina	n8			5.1		215	170
	s4			4.4		215	170
	s5			4.9		215	170
	μ10					325	250
englerti	s1	21	16	11.9	190	75	80
erosa	t5			9.5		115	115
	-	33	19				
	-	35	18				
	-	27	13.5				
errones sp.1	n4			11.8		80	75
sp.2	n4			12.8			
sp.4	*>50*			14.7			
erythraeensis	o6	19	5	17.6	90	60	65
esontropia	x5			12		95	70
(Madagascar)	ξ1	16	12.2	12.3	150		50
(Mauritius)	ξ2	14	6.5	16.3	105	80	45
	ξ4			11.3		95	65
exusta	λ12			9.6		150	205
fallax	z10			12.5		90	70
felina	l12			16.6		70	55
fimbriata	h5			21		70	60
	h6			24			
	h7			21		70	60
	l11			26.2		75	60
friendii thersites	γ10	84	36	3.4	120	290	365
friendii vercoi	β6	23					
	β7		29	6	175	255	250
fultoni	δ9			3.8		305	230
fuscodentata	w5	36	20	5	100	185	135
fuscorubra	v12		29	3.9	110	285	205

gambiensis	x10			8.9		145	105
	v1	34	15.5	9.6	150	115	90
gangranosa	z9			10.6		80	85
	γ1	65	18	14.5			
	γ2			21.7			
gaskoini	e9			30		30	30
globulus	v2			22.6		60	55
gondwanalandensis	y11					230	150
goodallii	s3			25.2		50	55
gracilis	e10			11.4		125	100
	174B	17	9.5				
granulata	λ9	32	19.5	9.3	180	225	150
grayana	q2	41	32	5	155	195	150
	μ11					240	145
guttata	p7	51	25	7	170	225	145
	p8	62	32	4	130		
	-	60	39				
hammondae	>61			24.7		60	60
helvola	g1			8.6		105	90
	i9			8.2		150	105
	i10					110	100
hesitata	γ8	66	28	3.1	85	310	225
hirasei	v2			4.4		285	170
hirundo	r10			23.1		50	60
	155B	16	6				
histrio	α3			5.3		300	220
	v5	56	30	4.8			200
hungerfordi	u12			6		155	115
interrupta	ϵ5	20	4	18.6		65	60
	-	19	5.5				
	-	18	4.5				
	-	18	4.5				
irrorata	h9			18.6		55	45

isabella (Hawaii)	q10	20	12	8.3	100	135	115
(Hawaii)	q6	34	30	5.2	155	225	200
	l3			12.2		120	105
	-	25	16				
	-	25	18.5				
isabellamexicana	p11			6.6		160	160
	-	29	13				
	-	37	16				
	-	25	10				
	-	25	12				
iutsui	δ12			4.3		260	260
	ξ8			6		210	160
jeaniana	γ5	69	31	3.9	120	325	285
	δ1			3.5		270	315
	ξ5			3.8		265	325
katsuae	t8			14.5		125	75
kieneri	r11			18.1		50	60
kingae	z11			11.8		85	60
kuroharai	y4			9.4		100	120
labrolineata	m2	20	11	14.3	155	70	60
	e12			11		110	90
	192B	16	9.5				
lamarckii	γ4	40	17	5.1	85	185	200
langfordi	λ10					405	250
latior	ν7		14.5	4.9	70	160	185
lentiginosa	o2			15		75	80
leucodon	c2	83	58	5	290	190	300
	g10	83	58	5	270	200	300
	ε7		49	4.5	220	225	290
leviathan	w10			7.1		165	280
limacina	n6			12.8			
lisetae	π6					65	55
luchuana	ζ6	17	9.7	13.5	130	65	70
	y6		6.5	14.4	95	45	50
	z8	18	5.5	13.8	75	75	65
	z8	19	6.5	13.9	90		

lurida	u5			5		235	325
lutea	z3	16	5	22.4	110	35	55
lynx	q8			15.6		65	95
	-	41	21				
	-	36	19				
	-	35	18.5				
	-	35	18				
macandrewi	y12	14	11	12.1	135	75	55
maculifera	q4			5.1		345	175
	q5			4.5			
mappa	l8			5.9		370	260
mappa alga	θ9			3.6		310	250
	-			3			
margarita	o11			32.1		35	35
marginalis	δ5	31	15	6.2	95	145	145
marginata	l10	60		7		235	225
mariae	η4	12	8.5	27	230	35	65
	v1					35	65
	-	15	11				
	-	13	9.5				
martini	k7			19.8		85	55
mauiensis	r9			23.3		40	45
mauritiana	r6			3.8		335	240
mayi	v9	22	12	14.7	175	105	95
microdon	i6			17.7		70	50
sp.1	ϵ12	10	4.7	29.4	140	70	50
sp.2	ϵ12	12	4.8	29.5	140	50	40
mikeharti	w2			9.7		110	75
miliaris	γ11	39	23	4.6	105	175	185
minoridens sp.1	ϵ11	11	4.5	24	110	45	45
sp.2	ϵ11	12	4.9	25.8	125		
	m1			26.5			
moneta	r3			12.6		75	104
mus	x4			5.5		185	170

nebrites	z4	29	14	10.6	150	100	90
	α4	27	10	9.7	100		
nigropunctata	t10			5.7		215	125
nivosa	v11	38	19.5	8	155	115	170
nucleus	l1			18.7		50	60
obvelata	i12			12.8		90	85
	f12			9.4			
	227B	20	16				
	228B	18	12				
	229B	17	10.5				
	230B	17	13				
	232B	18	12				
ocellata	δ4	24	13	6.9	90	90	100
onyx	p6			12.3		115	105
onyx (strange one)	o1			22		90	100
	125B	38	17				
ovum	p4	27	15	7.9	120	135	105
	177B	28	18.5				
owenii	λ5			16		75	75
pallida	ϵ1	25	13.5	6.9	95	145	120
	ν4			10.5		80	90
pallidula	α6	17	4	14.6	60	90	90
pantherina	λ3					345	275
	β12	89	42	4.2	175	270	265
petitiana	y1			10.1		100	80
	y3			10.7		110	75
	241B	26	16				
picta	η9	24	19	7.6	145	120	110
	λ11					120	115
piperita	x1	21	10	7.9	80	135	165
	-	24	9				
	-	22	12.5				
	-	23	13				
poraria	g6			9.3		110	100
propinqua	d3			10.7		85	105
pulchella	ξ9			6.8		160	155

pulchra	λ6					250	225
	q3	65	52	4.9	250	320	335
pulicaria	ζ10	23	9.5	8.4	80		105
	ζ11			8.6			115
	ζ12	26	8	7.2	55	125	100
punctata	i3			14.2		70	65
	m3			15.5		75	65
	o8			17.7		60	55
pyriformis	α5	23	10.5	26.5	275	60	50
pyrum	ϵ2	33	15.5	9.1	140	125	95
	λ4					155	110
quadrimaculata	p3			15.9		105	75
rabaulensis	α12			16.9		85	70
rashleighana	e8			15.4		100	70
reevei	β5		39	7.1	275	145	200
robertsi	θ10					125	125
	o9			9.1		125	90
rosselli	k2	45		13		155	165
	l5			8		155	180
sakuraii	y9			3.8		200	210
sanguinolenta	x12			11		80	85
saulae	r4			24		55	55
saulae jensostergaardi	*r5*			32		35	35
schilderorum	w6			14.9		65	85
	w11			10.8			
	-	27	23.5				
	-	26	20				
	-	27	16				
scurra	n7			7.3		155	105
semiplota sp.1	j5			7.5		110	145
sp.2	j5					70	90
serrulifera	o7	9	4.7	14.5	70	80	45
	176B	8	4.4				

spadicea	t7			4.1			160
	j3			4.4			
	s9			3.8			
	s10			4.7			165
	s12			3.3			165
spurca	x7	13	12.5	8.6	105	120	85
spurca acicularis	n9			8.2		115	80
spurca atlantica	α7			12.8		85	60
spurca sanctaehelenae	k4			9.6		115	85
staphylaea sp.1	m11			16.8		55	90
sp.2	m11			7.9		80	120
staphylaea cosobrina	o10			15.2		55	80
stercoraria	z5	70	47	3.8	180	195	200
	x11	77	55	4.2	230	355	195
stolida	e11			25.2		70	85
sp.1	m10			18.2		40	70
sp.2	m10			31.7			70
	n2			21.6			70
subteres	y7	26	7	11.4	80	105	115
subviridis	w8			18.2		130	125
	181B	29	14				
sulcidentata	l7			13.4		65	105
	-	31	22				
summersi	n5	16	3.5	26.9	100	55	40
surinamensis	λ2			10.1		125	130
talpa	n3	75	29	13.3	385	150	150
	p2	44	16	17.5	280		105
	p12	46	14.5	17.6	225	110	115
teramachii	g12	57	32	3.5	105	250	240
teres	q7	26	12	6.4	80	130	160
tessellata	z6	29	19	9.3	175	175	130
testudinaria	x6			2.7		580	365
teulerei	r8			3.6		255	130
thomasi	ξ3	11	6.9	17.9	125	85	50

tigris	m9			4			320
tigris schilderiana	l9	114	16.5	3.1			400
	p1			3.1			420
trenberthae	x2	22	7.5	11.5	85	100	100
turdus	ζ2	53	30			210	185
	γ3	40	23	5	105	230	200
turdus miyokoae	α2	42	20	7.6	150	125	110
ursellus	r12			10.6		40	70
valentia	ϵ8		32.5	2.8	90	400	280
	-	90	70				
	-	91	71				
ventriculus	y2			7.2		120	160
venusta	l6	54	32	3.6	110	355	270
vitellus	m7			7.3		125	215
vitellus polynesiae	c3			7.1		170	205
vredenburgi	ν3			7.1		130	120
walkeri sp.1	t3			8.2		110	95
sp.2	t3			7.3		125	100
wilkinsi	156K						
xanthodon	η7	27	12.2			150	130
	o4		14	8.3	110	155	110
	-	25					
yaloka	j10			31.2		50	55
	m12			40			35
	-	19					
zebra	l4			4.7		410	245
	μ12			4.3			260
ziczac	r2			40.3		55	50
zonaria	η6	37	16.5	8.9	145	125	125
	x10			8.9			105

APPENDIX III. PUBLICATIONS THAT DEPICT COWRIE RADULAR TEETH
(through July 1996)
(d=drawing; o=optical photo; s=SEM photo)

ADAM, W. & E. LELOUP

1938. Résultats scientifiques du voyage aux Indes Orientales Néerlandaises de LL. AA. RR. le Prince et la Princesse Léopold de Belgique. *Prosobranchia* et *Opisthobranchia*. Mémoires du Musée Royal d'Histoire Naturelle de Belgique, 2 (19): 1-209, pls. 1-8. [Fig. 36, p. 135 depicts cowrie radula.]
d:*annulus*.
s:*lamarckii*.

ANONYMOUS

1971. [Untitled. Short note, plus reprint of unnumbered figure from Schilder, 1968]. Hawaiian Shell News 19 (7): 6.
d:*midwayensis*.

ANONYMOUS

1986. Notes and tidings: *Cypraeovula (Luponia) mikeharti* n.sp. La Conchiglia 18 (206-207): 4-5, 14 figs.
d:*mikeharti*.

AZUMA, MASAO

1960a. A catalogue of the shell-bearing Mollusca of Okinoshima, Kashiwajima and the adjacent area (Tosa Province) Shikoku, Japan. Ohne Ort, 102 + 17 pp., pls. 1-5. [Pl. 5, figs. 3 & 4 depict cowrie radulae.]
d:*schilderorum, teramachii*.

1960b. Studies on the radulae of Japanese Cypraeacea. 1. Hyogo Biology 4 (1): 50-55, figs. 1-34. [Figs. 15-34 depict cowrie radulae.]
d:*annulus, arabica, artuffeli, caputserpentis, carneola, clandestina, gracilis, hirasei, hungerfordi, labrolineata, langfordi, miliaris, moneta, onyx, poraria, talpa, teramachii, teres, testudinaria, vitellus*.

1963. The radula of *Cypraea (Erosaria) guttata azumai* Schilder. Venus 25 (1): 50-51, fig. 1.
d:*guttata*.

AZUMA, MASAO & KAZUO KUROHARA

1967. A new cowry collected from off Midway Island. Venus 26 (1): 1-3, fig. 1.
d:*midwayensis*.

BANDEL, KLAUS

1984. The radulae of Caribbean and other Mesogastropoda and Neogastropoda. Zoologische Verhandelingen 214: 1-188, figs. 1-346, pls. 1-22. [Pl. 7, figs 3-5 & figs. 129-142 depict cowrie radulae.]
d:*annulus, arabica, camelopardalis, carneola, caurica, cinerea, crassites notata, erosa nebrites, erythraeensis, isabella, lynx, pantherina, spurca, staphylaea, tigris, turdus, zebra*.
s:*cinerea, spurca, zebra*.

BARLETTA, GIORGIO & ADRIANA CASTELLI

1978. Nota sul ritrovamento di quattro esemplari vivi di *Cypraea macandrewi* Sowerby, 1870, in Mar Rosso (Gastropoda: Cypraeidae). Conchiglie 14 (11/12): 195-204, pl.1, 1 unnumbered pl.
s:*macandrewi*.

BARNARD, K.H.

1963. Contributions to the knowledge of South African marine Mollusca. Pt. 3: Gastropoda: Prosobranchiata: Taenioglossa. Annals of the South African Museum 47 (1): 1-199, figs. 1-37.
d:*fuscorubra*.

BERGH, RUDOLPH

1908. Malacologische Untersuchungen. *In*: Semper, C. Reisen im Archipel der Philippinen; C.W. Kriedel's Verlag, Wiesbaden: 9 (6): 178 pp., 296 numbered figs. in 12 pls. [Pl. 12, figs. 27-34 & 36-37 depict cowrie radulae.]
d:*errones, lynx*.

BERTSCH, HANS

1984. *Jenneria pustulata*, the pustulate "cowrie." Opistobranch 16 (2): 10, figs 1-3.
d:*pustulata* [after Thiele, 1931].

BIRAGHI, GUGLIELMO

1975. Cowries...but not quite. La Conchiglia 7 (73-74): 12-13, 7 figs.
d:*adamsonii, pustulata*.

BRADNER, HUGH

1979. The sharp-tongued mollusks. The Festivus 11 (2): 9-15, figs. 1-16.
s:*depressa, fimbriata, granulata, isabella, isabellamexicana, lynx, poraria, tessellata, vitellus*.
d:*tessellata* [after Kay, 1957], *annettae* [after D'Attilio, personal drawing].

1983. SEM studies of Cypraea radulae. The Festivus 15 (6): 57-63, figs. 1-15.
s:*annulus, asellus, caputserpentis, lynx, obvelata, onyx melanesiae, schilderorum, semiplota, stolida fluctuans, teres, tessellata, vitellus*.
d:*caputserpentis, schilderorum, teres, tessellata* [after Kay, 1957].

1984. Try this on your stereopticon. Hawaiian Shell News 32 (11): 10, 1 fig.
s:*surinamensis*.

1985. *Cypraea annettae* Dall, 1909 vs. *C. aequinoctialis* Schilder, 1933; a statistical, optical, and SEM comparison. The Festivus 17 (6): 54-58, figs. 1-6.
s:*aequinoctialis, annettae*.

1987a. Comparisons between John Earle's Easter Island cowrie and *Cypraea cernica* Sowerby, 1870. The Festivus 19 (8): 75-79, figs. 1-4.
s:*cernica*.

1987b. Is John Earle's Easter Island cowry *C. cernica* Sowerby, 1870? Hawaiian Shell News 35 (10): 8, figs. 1-3 + 1 unnumbered fig.
s:*cernica*.

1989. *Cypraea luchuana* as a valid species. Hawaiian Shell News 37 (6): 5, 2 figs.
s:*luchuana, pallidula*.

1991. A remarkable cowrie radula. The Festivus 23 (1): 3-5, figs. 1-5.
s:*onyx melanesiae, talpa*.

1993a. *Cypraea luchuana* as a valid species: a correction. Hawaiian Shell News 41 (11): 12, 2 figs.
s:*luchuana, pallidula*.

1993b. Two odd-ball Cypraeacea: *Jenneria pustulata* and *Pseudocypraea adamsonii*. The Festivus 25 (9): 80-82, figs. 1-8.
s:*adamsonii, pustulata, isabella.*
d:*adamsonii* [after Thiele, 1931], *pustulata* [after Thiele, 1931], *isabella* [after Kay, 1960].

BRADNER, HUGH & E. ALISON KAY

1995. Techniques in preparing and photographing *Cypraea* radulae. The Festivus 27 (8): 96-103, figs. 1-6c.
s:*artuffeli, cernica, lynx, surinamensis.*

BURGESS, CLARENCE M.

1985. Cowries of the World. Seacomber Publications, Cape Town, South Africa: xiv + 289 pp., 20 pls., numerous figs.
s:*maculifera.*
o:*cinerea, isabella, leviathan.*

CALVO, IARA S.

1987. Rádulas de gastrópodes marinhos Brasileiros. Editoria da Furg, Rio Grande, Brazil: 201 pp., 165 figs.
d:*cinerea, spurca acicularis, zebra.*

CERNOHORSKY, WALTER O.

1963. New locality record for *Cypraea walkeri bregeriana* Crosse, 1868. Hawaiian Shell News 11 (8): 5-6, figs. 1-4 + 1 unnumbered fig.
d:*bregeriana.*

1969. *Erronea rabaulensis* (Schilder, 1964) from the Solomon Islands. Hawaiian Shell News 17 (1): 7, figs. 1-4.
d:*rabaulensis.*

1971. Marine Shells of the Pacific, Revised Edition. Pacific Publications Pty. Ltd., Sydney, NSW. 248 pp., figs. 1-21, pls. 1-60.
d:*limacina.*

CRAM, DON

1973. *Notocypraea* - valid species and variations. Australian Shell News 4: 6-7, 12, figs. 1-4, 13 unnumbered figs.
d:*angustata, comptonii*, declivis, piperita.

CROVO, M. ELLEN

1971. *Cypraea cervus* and *Cypraea zebra* in Florida - one species or two? The Veliger 13 (3): 292-295, figs. 1-7.
o:*cervus, zebra.*

DOLIN, LUC & PHILIPPE BOUCHET

1986. When two mythic shells become real. Rossiniana 32: 19-28, 8 figs.
s:*teramachii.* [badly fractured, one view]

GOSLINER, TERRENCE M. & WILLIAM R. LILTVED

1985. Aspects of the morphology of the endemic South African Cypraeidae with a discussion of the evolution of the Cypraeacea and the Lamellariacea. Annals of the South African Museum 96 (4): 67-122, figs. 1-35.
s:*algoensis, capensis, coronata, cruickshanki, edentula, fuscodentata, fuscorubra, iutsui.*
d:[Same set as above.]

GRAY, JOHN EDWARD

1853. On the division of ctenobranchous gasteropodous Mollusca into larger groups and families. Proceedings of the Zoological Society of London, 21: 32-44, figs. 1-26.
d:*helvola.*

GRIFFITHS, R. JOHN

1957. Some Malayan cowries. Malayan Nature Journal 11: 104-113, figs. 1-8, 3 unnumbered figs., pls. 52-53.
d:*arabica, errones, hirundo, lamarckii, onyx, ovum, pallida, quadrimaculata.*

1959. A new species of the *Cypraea* subgenus *Noctocypraea*. Memoirs of the National Museum, Melbourne 24: 97-101, fig.1, pl. 1.
d:*comptonii.*

1962. A review of the Cypraeidae genus *Noctocypraea*. Memoirs of the National Museum of Victoria 25: 211-231, pls. 1-4.
d:*angustata, comptonii, declivis, piperita, pulicaria, dissecta (piperita), emblema (angustata), euclia (pulicaria), molleri (angustata), wilkinsi (comptonii).*

KAY, E. ALISON

1957. The systematics of the Cypraeidae as elucidated by a study of *Cypraea caputserpentis* and related forms. A thesis submitted to the Graduate School of the University of Hawaii. vii + 271 pp.
d:*annulus, arabica, caputserpentis, carneola, caurica, cervus, cinerea, cribraria, depressa, erosa, errones, fimbriata, goodalli, granulata, helvola, hesitata, hirasei, isabella, kieneri, lamarcki, lynx, mauritiana, miliaris, moneta, nucleus, obvelata, pallida, poraria, pyriformis, pyrum, reticulata, schilderorum, scurra, spadicea, spurca, staphylaea, sulcidentata, talpa, teres, tessellata, tigris, vitellus, zebra.*

1960a. The functional morphology of *Cypraea caputserpentis* L. and an interpretation of the relationships among the Cypraeacea. Internationale Revue der gestamten Hydrobiologie 45 (2): 175-196, figs. 1-18.
d:*caputserpentis.*

1960b. Generic revision of the Cypraeinae. Proceedings of the Malacological Society of London 33 (6): 278-287, figs. 1-8.
d:*caputserpentis, isabella, schilderorum, sulcidentata, teres, tessellata.*

1961. Anatomical characters which distinguish two species of *Cypraea*. Proceedings of the Malacological Society of London 34 (4): 199-202, figs. 1-2.
d:*carneola, leviathan.*

1963. Anatomical notes on *Cypraea aurantium* Gmelin and other cowries and an examination of the subgenus *Lyncina* Troschel. Journal of the Malacological Society of Australia 1 (7): 47-61, figs. 1-12, pl. 8.
d:*argus, aurantium, carneola, leviathan, lynx, mappa, reevei, schilderorum, sulcidentata, talpa, testudinaria, vitellus.*

1979. Hawaiian Marine Shells. Reef and Shore Fauna of Hawaii, Section 4: Mollusca. Bernice P. Bishop Museum Special Publication 64 (4): xvii + 653 pp., frontis. + 195 figs. [Figure 22B is *Cypraea semiplota*].
s:*semiplota.*

1981. A new species of *Cypraea* from the Hawaiian Islands and a discussion of the *C. teres* species complex. Venus 40 (3): 111-122, figs. 1-3.
d:*burgessi, rashleighana, teres.*

1985. About the cowries. *In*: Burgess, C. M., Cowries of the World. Seacomber Publications, Cape Town, South Africa: pp.4-11, figs. 1-2.
s:*maculifera.*
o:*cinerea, isabella, leviathan.*

KAY, E. ALISON & OLIVE SCHOENBERG-DOLE

1991. Shells of Hawai'i. University of Hawaii Press, Honolulu: 89 pp., frontis. + 141 figs.
s:*semiplota.*

KILBURN, RICHARD N.

1972. A new cowrie from deep water off Natal, with notes on

allied species (Mollusca: Gastropoda: Cypraeidae). Durban Museum Novitates 9 (14): 209-216, fig. 1, pls. 1-2.
d:*cruickshanki*.

KILBURN, RICHARD N. & D.W. AIKEN
1972. Notes on two endemic South African *Cypraea*. The Veliger 15 (2): 125-126, fig. 1.
d:*capensis, fultoni*.

LILTVED, WILLIAM R.
1983. A new *Cypraea* from South Africa (Gastropoda: Cypraeidae). Venus 42 (3): 234-240, fig. 1, pl. 1.
d:*algoensis, connelli*.
1989. Cowries and Their Relatives of Southern Africa. Seacomber Publications, Cape Town, South Africa: 208 pp., 298 figs. + numerous unnumbered figures.
s:*alfredensis, iutsui*.
d:*connelli*.

LIVERSIDGE, M.J.H.
1968. On the distribution of *Cypraea (Erosaria) marginalis* along the east coast of Africa. Journal of Conchology, 26 (4): 229-236, figs. 1-2.
d:*marginalis*.

LORENZ, FELIX JR.
1985. Eine neue *Cypraeovula* aus Südafrika (Gastropoda: Cypraeadae, Cypraeovulinae). Heldia 1 (3): 95-98, fig. 1, pls. 13, 14a.
d:*algoensis, mikeharti*.
1988a. Considerations on the complex of *Umbilia hesitata* Iredale, 1916 in Keppel Bay, Queensland (Gastropoda: Cypraeidae). La Conchilgia 19 (230-231): 14-20, 6 figs.
d:*hesitata* [after Vayssière, 1923].
1988b. *Staphylaea limacina* Lamarck, 1810, in the western Indian Ocean. La Conchiglia 20 (228-229): 16-18, 2 figs.
d:*limacina* [5 forms], *semiplota, staphylaea*.
1989. Annotated descriptions of some new and old members of Cypraeidae. Schriften zur Malakozoologie 2: 1-38, figs. 1-12, pls. 1-7.
d:*algoensis, cribraria, edentula, mikeharti*.
1990. News on *Cypreaovula edentula nahoonensis*. Schriften zur Malakozoologie 3: 21-22, pl. 5.
d:*edentula*.
1991. Description of a new species of *Barycypraea fultoni* (Sowerby 1903) with notes on the genus *Barycypraea* Sowerby, 1903 (Mollusca: Cypraeidae). Schriften zur Malakozoologie 4: 27-38, figs. 1-12, pls. 5-6.
d:*fultoni fultoni, fultoni massieri*.
1992. On the identity of *Cypraea tortirostris* Sowerby III, 1906. Parasitism as a possible reason for malformations in Cypraeidae and some new facts on *E. chinensis*. Schriften zur Malakozoologie 5: 63-66, figs. 1-5, pl. 19.
d:*chinensis*.
1993. A new eastern subspecies of *Cypraeovula coronata* Schilder, 1930, with a review of the species. *In*: Lorenz, F. & Alex Hubert, A Guide to Worldwide Cowries. Verlag Christa Hemmen, Wiesbaden, Germany: pp. 563-567, figs. A1-A5, appendix.
d:coronata, fuscodentata.
1995. *Bistolida owenii vasta* in Tanzania. La Conchiglia 27 (276): 54-55, 3 figs.
d:*owenii*.

LORENZ, FELIX JR. & ALEX HUBERT
1993. A Guide to Worldwide Cowries. Verlag Christa Hemmen, Wiesbaden, Germany: 571 pp., numerous figs., 124 pls.
o:*arabica*.
d:*achatidea, argus, capensis, carneola, clandestina, erosa, errones, fimbriata, friendii, fultoni, lentiginosa, leviathan, leviathan titan, lynx, marginalis, mus, picta, robertsi, spadicea, testudinaria, tigris, vitellus, zebra*.

LORENZ, FELIX JR. & VOLLRATH WIESE
1990. A new subspecies of *Erosaria marginalis* with a note on *Erosaria pseudocellata* (Gastropoda: Cypraeidae). Schriften zur Malakozoologie 3: 11-20, figs. 1-5, pls. 3-4.
d:*marginalis*.

LOVEN, SVEN L.
1847. [Om tungans bevapning hos mollusker (Clio borealis, Hyalaea trispinosa, Limacina arctica, Doris obvelata, etc.)] Ofversigt af Kunglia Vetensk Akademiens Forbandlingar, Stockholm: 175-199, numerous figs. [*Cyp. helvola* radula depicted in unnumbered fig. in Table 4].
d:*helvola*.

LUQUE, ANGEL
1980. El género *Schilderia* Tomlin, 1930 (Gastropoda, Cypraeidae) Communicaciones de Primero Congreso Nacional de Malacologie, Madrid: pp. 51-62. 4 figs.
d:*achatidea, hirasei, langfordi, langfordi moretonensis, midwayensis, pyrum, teramachii*.
s:*achatidea*.

LUTHER, FRED
1972. Al Masira - Teuleri Island. Hawaiian Shell News 20 (9): 1, 3, 8 figs.
d:*teuleri*.

MASSIER, WERNER
1993. Description of a new subspecies of *Cypraeovula capensis* (Gray 1828) (Gastropoda: Cypraeidae). Schriften zur Malakozoologie 6: 21-26, fig. 1, pl. 5.
d:*capensis*.

OKUTANI, TAKASHI
1974. A new locality of *Schilderia (Kurodadusta) teramachii* (Kuroda, 1938) (Gastropoda: Cypraeidae) Venus 33 (3): 147-149, figs. 1-3.
d:*teramachii*.

ORR, JOHN D.
1984. Tracking down *Cypraea vredenburgi*. Hawaiian Shell News 32 (3): 3-4, 4 figs.
s:*pallida, vredenburgi*.
d:*pallida, vredenburgi*.
1985. Hong Kong Seashells. Urban Council of Hong Kong: iii + 122 pp., 94 pls.
d:generalized form.
o:*caurica, fultoni*.

OSORIO R, CECILIA
1989. La radula de *Cypraea caputdraconis* Melvill, 1888 (Molusca: Gastropoda). Revista de Biologia Marina 24 (2): 149-153, figs. 1-3.
s:*caputdraconis*.

PEILE, A.J.
1922. Some notes on radulae. Proceedings of the Malacological Society of London 15 (1):13-18, figs. 1-8.
d:*caputserpentis* [including radula with double centrals].

RAYBAUDI MASSILIA, LUIGI

1991. Genus *Zoila* Jousseaume, 1884. A new species from Western Australia. La Conchiglia 22 (260): 8-15, 11 figs.
o:*"decipiens", "jeaniana", "eludens"*. [radulae questionably *Zoila*]

REHDER, HARALD A. & BARRY R. WILSON

1975. New species of marine mollusks from Pitcairn Island and the Marquesas. Smithsonian Contributions to Zoology 203: 1-16, figs. 1-10, pl. 1.
d:*kingae*.

RISBEC, J.

1937. Anatomie des Cypraeides. Archives du Museum National d'Histoire Naturelle. 6th ser. 14: 75-104, pls. 2-7.
d:*arabica, caputserpentis, erosa, hirundo, tigris*.

ROBERTS, S. RAYMOND

1885. Monograph of the family Cypraeidae. *In* Tryon, George W. Jr., Manual of Conchology 7: 153-240, pls. 1-23, Academy of Natural Sciences, Philadelphia. [Fig. 8 in pl. 15 & fig. 41 in pl. 20 depict cowrie radulae.]
d:*staphylaea, tigris*.

SCHILDER, FRANZ A.

1926. An interesting radula (*Eocypraea adamsonii* Sow.). The Nautilus 40 (1): 17-18, fig. 1a-1e. ["Partially drawn wrong" per Schilder.]
d:*adamsonii*.

1932. Beitrage zur Kenntnis der Cypraeacea: V (15: Cypraeidae von den Sudlichen Marianen. 16: Die Radula einiger bisher nur als Schalen bekannter Arten. 17: Uber einige sehr seltene Cypraeidae). Zoologischer Anzeiger, 100 (7/8): 164-173, figs. 1-19.
d:*arabicula, capensis, caurica, cervinetta, cinerea, coxeni, felina, hirundo, lentiginosa, nucleus, pulchella, robertsi, sulcidentata, zonaria*.

1936. Anatomical characters of the Cypraeacea which confirm the conchological classification. Proceedings of the Malacological Society of London 22 (2): 75-112, pl. 2.
d:*arabica, capensis, carneola, cicercula, hirundo, isabella, pantherina, adamsonii*.

1963. An abnormal cowry radula. Proceedings of the Malacological Society of London 35 (4): 129-130, fig. 1.
d:*annulus* [normal & abnormal].

1965. Zur Kenntnis der Cypraeidae: 9. Eine zweite Ueberraschung aus Queensland. Archiv für Molluskenkunde 94 (1/2): 55-60, figs 1-5.
d:*hungerfordi, langfordi*.

1967. A rare cowrie species. Hawaiian Shell News 15 (4): 5, 2 figs.
d:marginata.

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